DOCUMENT RESUME

ED 231 643 SE 042 079

TITLE	Inservice Guide for MNCP Units. Teacher's Guide.
INSTITUTION	San Francisco State Univ., Calif.
SPONS AGENCY	National Inst. of Education (ED), Washington, DC.; National Science Foundation, Washington, D.C.
PUB DATE	81
GRANT	SED-80-12465
NOTE	142p.; For related documents, see SE 042 071-078.
PUB TYPE	Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE	MF01/PC06 Plus Postage.
DESCRIPTORS	*Computer Oriented Programs; Discovery Learning; Elementary Secondary Education; *Inservice Teacher Education; Mathematical Concepts; Mathematics Curriculum; *Mathematics Education; *Mathematics Instruction; *Microcomputers; Middle Schools; Problem Solving; Programing; Teacher Education; Teaching Guides; *Teaching Methods; Units of Study
IDENTIFIERS	*Math Network Curriculum Project

ABSTRACT

The seven units developed for the Math Network Curriculum Project (MNCP) incorporate an active approach to the study of mathematics using microcomputers. The intent is to have students explore new concepts by experimenting with different situations. Most teachers of mathematics have not learned mathematics in an active way, and thus need to experience the approach they will be expected to use with students. The Inservice Guide is intended to serve as a tool for a master teacher to introduce middle school teachers to the seven units and thus to an active approach to learning mathematics. It first reviews the MNCP philosophy and inservice plans. Then each unit is discussed in detail, so the teacher learns how to use it with students. (MNS)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION
CENTER (ERIC)
☑ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
● Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

ED231643

Inservice Guide for MNCP Units

Teacher's Guide

Math Network Curriculum Project

San Francisco State University

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
National Science Foundation
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

SE042079

Funded by the National Science Foundation and
the National Institute of Education
Project Number SED 8012465

Copyright 1981

TABLE OF CONTENTS

MNCP Units....................................page 2

Need for an Inservice Guide...................page 2

Who's a Master Teacher........................page 3

MNCP Philosophy...............................page 3

Inservice Philosophy..........................page 6

Scheduling the Inservice......................page 6

Input-Output Unit.............................page 8

    Input-Output Worksheets...................page 15

Strategies Unit...............................page 26

    Strategies Worksheets.....................page 31

Business Unit.................................page 35

    Business Worksheets.......................page 41

Sampling Unit.................................page 52

    Sampling Worksheets.......................page 59

Data Analysis Unit............................page 70

    Data Analysis Worksheets..................page 77

Turtle Geometry Unit..........................page 91

    Turtle Geometry Worksheets................page 97

Symmetry Unit.................................page 113

    Symmetry Worksheets.......................page 117

MNCP UNITS

The seven Math Network Curriculum Project Units were developed at San Francisco State University during 1981 under a grant from the National Institute of Education and the National Science Foundation. The co-directors of the grant were William Finzer, Jose Gutierrez and Diane Resek. Joan Akers joined the directors in development work during the summer of 1981.

The units integrate the use of microcomputers into the teaching of middle school (6th through 8th grade) mathematics. The units were field-tested by eleven middle school teachers in the San Francisco area in Fall 1981 and were rewritten in Spring 1982.

NEED FOR AN INSERVICE GUIDE

The MNCP units incorporate an active approach to the study of mathematics. We intend for students to explore new concepts by experimenting with different situations. On the face of it, one might think the role of a teacher in an active learning environment is less than in a traditional classroom. However, we have found that a curious, knowledgeable, and sensitive human teacher is essential if we want students to grapple with conflicting ideas and to reach higher levels of abstract thinking.

Most teachers of mathematics themselves have not learned mathematics in an active way. Many tend to view the subject as a set of definitions and facts to be mastered in a rote manner. This view is reinforced by most mathematics textbooks. If teachers are to use the MNCP units in the manner prescribed within each unit, they need to be already aware of the active approach to learning mathematics, or they must experience this approach themselves.

The intention of the MNCP Inservice Guide is to serve as a tool for a Master Teacher to introduce middle school teachers to the seven MNCP units and, thus, to an active approach to learning mathematics.

WHO'S A MASTER TEACHER?

Ideally, a Master Teacher of the MNCP units is someone who has used the units with one or more classrooms of students. Given that ideal situations are not always possible, a Master Teacher for these units should have a deep interest and sound knowledge of mathematics and classroom experience in teaching mathematics actively. One essential qualification for such a teacher is the **time** to explore each unit and all its associated activities completely before presenting these activities to other teachers.

We envision master teachers as being experienced classroom teachers, curriculum specialists, school district or county administrators, or college instructors. The Master Teacher may want to hold only one inservice session and present a single unit, or she/he may wish to present all seven units in a series of sessions. Another possibility would be to present one or more units in a course on methods of teaching mathematics or on computers in classrooms.

MNCP PHILOSOPHY

The seven units have in common an imbedded philosophy about math learning, the use of computers in math classrooms, their intended audience, and classroom organization.

Math Learning

We believe that mathematics learning should involve the student's mind in an active way, should emphasize patterns, and should proceed from concrete situations toward abstract generalizations.

The function of all education, and mathematics education in

particular, is to help people become capable, creative, and flexible members of our society. To carry out this function, students must be allowed to experiment, create, and to question. They must become **actively** involved in finding relationships and implementing their own ideas. The MNCP units were developed to involve students in an active way with mathematical ideas.

Much of the work in the units asks students to discover **patterns** and gives them the opportunity to generalize them. The search for patterns is the core of the work of professional mathematicians and is the key to understanding mathematics at all levels. If middle school students are able to see the relationship of pattern searching to mathematics learning and become skilled in finding such patterns, we believe that their study of mathematics in high school and college will be much smoother.

In these units, ideas are introduced as concretely as possible and related to the students' experiences. Opportunities then are provided for students to explore these ideas in new environments more abstracted from their own experiences. Thus, students can form a deeper understanding of the ideas and will be able to apply them to other situations. It is the teacher's job to help make transitions from the familiar to the foreign.

Use of Computers

Computers hold exciting promise for making the learning process more creative and much more practical. Through computer simulations we can create learning environments which supplement the real world of paper, wood, chalk, test tubes, trees, animals, and other human beings. For many learning purposes, the simulated computer world is superior to the real world in that it can have a degree of simplicity or complexity to fit the needs and level of the students.

We have tried to use computers as fully as possible to reproduce real-world uses of the computer (cf. "Cosmic Explorer" in the Data Analysis Unit); to create imaginary worlds where mathematics is needed to function (cf. "Turtletalk" in the Turtle Geometry Unit); and to provide a needed transition between concrete and abstract activities (cf. "Guess My Bag" in the Sampling Unit).

However, we have also tried hard to remember that computers are just one tool in a teacher's arsenal; and, although they may be the best tool for certain purposes, they are surely not the best tool for all purposes. Thus, most of the activities in the units do not involve computers; rather, they involve physical objects, games, worksheets, and class discussions. The computer programs were designed to be used in an integrated way with other activities. They should not be used by themselves.

Although computers can be used effectively for drill and practice or for programmed learning, we chose not to use them in these ways. Rather, we set up situations where students control the computer as a tool to actively explore new concepts. We hoped computers could provide for interaction between students and ideas. In fact, the computer activities were intended to be playgrounds of ideas where students experiment with parameters. They can try to predict what will happen, discuss results, and challenge each other's hypotheses.

INSERVICE GUIDE FOR MNCP UNITS

Intended Audience

Computers are frequently used exclusively with groups of high achievers (for enrichment) or with low achievers (for remediation). We designed the units to be used with heterogenous classes. The activities should be accessible to everyone, with all students being challenged at their own level. Since the students are in control of the computer, they can choose, in many instances, their own level of complexity and abstraction to work on.

Classroom Organization

All of the units are designed for classrooms with at least two 16-K PET computers. This means that only some of the students in a class can work on computers at one time. Except during the Turtle Geometry Unit and part of the Input-Output Unit, teachers will need to have prepared work from outside the units for the rest of the class to work on while some students use the computers. Since students need little teacher direction during computer activities, and since the units can be only a part of the middle school mathematics program, teachers have not found it a problem to interweave the computer activities into their curriculum. Teachers should be aware that they need to schedule the computer use and that they need to establish an understanding with students as to how other work will be made up when they are on the computer. Middle school students can be made responsible for asking other students for assigments or directions they missed while on the computer.

All computer work and much of the non-computer work in the Units is carried out by students working in groups of two to four. The grouping shortens the time needed for all students to have computer access. However, the prime motivation for designing group activities was not to ease computer access. Rather, it was because we believe that students often learn better in groups. Working with others, they can share and criticize each other's ideas and, thus, can progress farther and more quickly than they could if they worked alone. By discussing seeming contradictions with each other, they will come more quickly to an accommodation with new ideas. Further, it is important in our society, where much problem-solving is done collectively, for students to learn to work with others in a cooperative way.

Teachers who previously have not tried having students work in groups tend to fear that students will become undisciplined when working in groups. We have found that, except in classes with real discipline problems, these fears are groundless. Teachers do need some reassurance that group work will be effective. It is especially helpful for teachers to have interaction with each other when they are first having students work in groups. They can share good ideas about setting and reinforcing rules with each other.

INSERVICE PHILOSOPHY

One important lesson from Math Education research is that teachers generally teach concepts in the way they learned those concepts themselves. Thus, if we want teachers to teach their students in an active way built on group problem-solving and concrete experiences, they must be exposed to learning (or re-learning) using these same methods. Thus, if teachers are to use the suggested methods when they teach the units, you, the Master Teacher, must use these methods in the inservice sessions. In our experience, almost all the teachers enjoy learning and working in these ways. The few who resist these methods can be somewhat comforted by hearing that most students learn best in these ways and that they need to experience what their students will do so that they will be prepared for pitfalls. Many teachers who resist guessing and exploration are feeling insecure by being taken out of a context of memory learning, a method that was successful for them.

The best way to present these units to teachers is over a long enough period of time so that they have a chance to begin teaching with a unit before their contact with you and with each other is cut off. This timing will give teachers a chance to share ideas with each other. We have learned many ways of improving the units from the teachers who field-tested them. There was not room to put all their good suggestions in the Teacher's Guides. Thus, there are not remedies for many problems in the Guides, but other teachers using any of the units will have good suggestions for someone using the unit. Probably most of the teachers you work with will be using the same curriculum and will have good ideas for each other on ways to integrate the units into the curriculum or ways to modify or extend the units so that they dovetail more neatly into the other work.

Even if teachers are not able to teach the units while they are still learning, they will have good ideas about how to use them. Since the timing for inservice sessions was set up to be as short as possible, only five minutes were left at the end of each session for discussion. If more time is available, you and the teachers will benefit greatly by longer discussions at the end of each session. It will be helpful if you have time at the end to go back and discuss potential pitfalls and extensions for each activity covered.

SCHEDULING THE INSERVICE

All inservice sessions on the individual units are planned for at least two hours. You should not spend less time on the units if you want teachers to feel comfortable teaching them. More time easily could be used for each unit on final discussion, the computer activities, and activities that are in the unit but not in the inservice plan.

If you have sessions that are shorter than two hours, there should be no problem in working with any unit over several sessions. Just remember to leave time for review. There is no preferred order for covering the units as long as any prerequisite unit has been covered previously. The **Data Analysis Unit** is a special case in that it requires 3 or 4 ten to fifteen minute periods to have taken place in previous sessions before the main body of the unit is covered in a two-hour session.

If you have additional sessions available, you might want to use time to look at and evaluate software that is not in the units. You may wish to cover fewer than all seven units in favor of looking at other kinds of software. It will be interesting for teachers to see some examples of drill and practice programs designed for programmed learning as well as more strategy games and simulations. After comparing a few MNCP units to the other software, teachers can begin to decide how they want to use computers in their classroom. They probably will want to design their own units around the other computer programs so that students will learn the concepts completely. Designing these units will be an excellent activity for small groups of teachers.

Another important activity for teachers will be discussing ways of getting more computers. Some teachers may need help from other teachers in convincing their school administrators to allow them to use computer curriculum with their classes. Role-playing sessions could help teachers think of ways to convince others.

Many of the teachers you work with will want to become or will need to become master teachers for other groups. If this is the case, try to leave time in a session for teachers to plan inservice sessions. You might brainstorm some important elements for inservice work before they begin to plan. In this way they will be more likely to include active, small group, and exploratory activities for their sessions.

INPUT - OUTPUT UNIT

Time 2 hours

Materials

- Overhead projector
- "Mystery Tower" transparency
- "Input-Output Machine" transparency
- 2 "Other Machines Worksheet" for each participant
- "Mystery Machines Worksheet" for each group of 4 teachers
- 1 "Examples of Conditionals" Worksheet for each participant
- "Wizard" computer program
- 1 "Wizard's Workshop Worksheet" for each group of 3 or 4
- 2 Sets of Cuisenaire Rods
- 50 Cubes
- 50 beans
- 2 Copies of each of the 8 "Wizards Workshop" experiments
- 1 "Easy Speak Summary Sheet" for each participant
- Easy Speak "Computer Program"
- 1 PET computer per 2 participants
- (If this is not possible, at least 1 computer for every 4 participants)

Suggested Time Frame

Time	Activity
5 min	Introduction
10 min	The Fable of the Wizards
15 min	Input-Output Machines
20 min	Mystery Machines
20 min	Wizard
20 min	Wizard's Workshop
5 min	The Human Computer
20 min	Easy Speak
5 min	Summary

Total: 2 hours

Overview for Master Teacher

The use of matematical symbols and phrases is difficult for many beginning algebra students. Students have little experience in speaking or writing matematics in a meaningful way. Anyone who has taught algebra understands that students have great difficulty in writing appropriate equations for word problems. Now the computer and an idea of Seymour Papert's[1] give us an opportunity to allow students to use mathematical symbols in a meaningful way before they meet word problems and formal algebra in high school.

Papert's idea is to use the computer to create a "Mathland", a motivating, often artifical environment where students must use math, or algebra, to survive. In this unit, the "Easy Speak" computer program presents a world where students use algebra to create Input-Output machines.

Input-Output machines stand for functions, which are important throughout mathematics. Most formulas can be thought of as functions. Thus, this unit provides students with an opportunity to become comfortable with functions and formulas before they meet them in more advanced courses.

In addition, the work with Input-Output machines requires students to search for patterns. This search is a way of thinking which is required throughout the study of mathematics (cf. the Overview of the Teacher's Guide for further explanation).

The unit begins with an introduction to Input-Output machines through "The Fable of the Wizards". The next three activities provide practice with machines and conditional statements while students learn to work in groups. The machines students work with are rules that do not arise from physical situations; rather, they are invented with no motivation except the challenge of finding a rule. In "Wizard's Workshop", students explore **concrete physical situations** which give rise to Input-Output machines. This concreteness is crucial to students' understanding of input-out machines (or functions) and to their later understanding of algebra. It is the one activity where mathematical rules are linked to activities in the physical world. Teachers should be cautioned not to skip this activity (even though it involves some work for them to collect the materials). In the same vein, it is important that master teachers do some of these activities with teachers; otherwise, the teachers may feel uncomfortable trying the activities with students.

The "Human Computer" activity introduces the language, "EASY SPEAK" (a version of of algebra) as a means for students to express Input-Output rules. Once students are comfortable with the Easy Speak language, they can use the "Easy Speak" computer to create their own Input-Output machines. The machines can be stored on the Network; thus, they can be analyzed by students from other classes.

---

[1] cf. Mindstorms by Seymour Papert, Basic Books, N.Y., 1981.

Introduction

Time 5 minutes

Materials None

You should make three points in the introduction:

This unit is prerequisite to others.

The subject may be unfamiliar but it is important.

Guessing is a useful technique for learning mathematics.

Prerequisite

The Input-Output Unit is prerequisite to two other MNCP units: Strategies and Business.

Important Subject

Although teachers may not have seen input-output machines or a language like Easy Speak, they embody important mathematical ideas: functions and algebraic notation. The unit will be most helpful in building an understanding of functions and symbolic notation.

Guessing

The procedure used in this unit will be finding patterns or rules by first guessing a rule and then checking whether their rule fits. If the rule does not fit, students must guess some more. Although guessing is traditionally discouraged in math classes, it is an important tool for mathematicians, which they label as "conjecturing" or "making hypotheses". Warn the teachers that they and their students might feel uncomfortable with this process at the beginning, since they've so often been discouraged from saying something that in mathematics classes may be wrong.

The Fable of the Wizards

Time 10 minutes

Materials
Overhead projector
Mystery Tower transparency

Go through the activity as described in the Teacher's Guide. Try to use the Teaching Notes described in this section of the guide whenever appropriate.

Input-Output Machines

Time 15 minutes

Materials
"Mystery Tower" transparency
overhead projector
"Input-Output Machine" transparency
1 "Other Machines Worksheet" per teacher

Ask the teachers to summarize the properties of Input-Output machines. In particular:

1. You input a number and another one comes out.

2. It does the same thing to each number.

3. The order you put the numbers in doesn't matter. (ie. if you put in 4 as the first number and as the sixth number, the machine will give the same answer.

Go over the teaching notes on page two with the teachers.

Introduce the T-shape (the table) as described in the Teacher's Guide.

Describe the Group of Four activity and discuss working in groups. Suggestions for teachers' using group work are in the Overview to the Teacher's Guide. Put the teachers in random groups of four and let them work on the activity.

Spend a few minutes at the end of the activity discussing the power that comes from group work (ie. 3 or 4 heads are better than one).

Mystery Machines

Time 20 minutes

Materials
Overhead projector
Input-Output Machine transparency
1 Mystery Machines Worksheet for each group of 4 teachers
1 Examples of Conditionals Worksheet for each participant

Using the transparency or a chalkboard, introduce the three Input-Output machines on page two of the Teacher's Guide:

```
1. CONDITION:  INPUT < 6
   OUTPUT = INPUT
2. CONDITION:  INPUT > 6
   OUTPUT = 10

1. CONDITION:  EVEN (INPUT)
   OUTPUT = INPUT + 1
2. CONDITION:  ODD (INPUT)
   OUTPUT = 20 - INPUT

1. CONDITION:  FACT (3, INPUT)
   OUTPUT = 11
2. CONDITION:  NOT (FACT(3, INPUT))
   OUTPUT = 2 * INPUT
```

Teachers will describe the rules for these machines in English, and you will show them how to use EASY SPEAK to write the rules.

Then have teachers work through the Mystery Machines worksheet in groups of four. If they work as a group, they will work much more quickly than as individuals. Ask the teachers to give hints to other group members rather than telling them the rules. All groups may not finish the entire worksheet in the time allotted. Explain the "Examples of Conditionals" worksheet, although they may not have time to work through it.

Wizard

Time 20 minutes

Materials

1 PET computer loaded with "Wizard" for half the groups of 3 or 4 teachers
1 "Other Machines Worksheet" for each group of 3 or 4 teachers

Half the teachers will work on Wizard while the other half works on Wizard's Workshop. Explain to the teachers that they can let groups of students rotate through this computer activity while other students do Wizard's Workshop or other class material.

The computer program should be self-explanatory. Teachers should record the seed number and table for each machine they attempt on the worksheet.

Wizard's Workshop

Time 20 minutes

Materials
- 2 "Wizard's Workshop" experiments for each of the 8 experiments
- 1 "Wizard's Workshop Worksheet" for each group of 3 or 4
- 2 sets of Cuisenaire Rods
- 50 cubes
- 50 beans

Prepare two Wizard's Workshop experiments for each of the eight experiments.

Have the teachers work in groups of 3 or 4 on the experiments. They probably won't have time to do more than 4 experiments, and some groups will do less.

The Human Computer

Time 5 minutes

Materials
- 1 Easy Speak Summary Sheet for each teacher
- 1 PET computer loaded with "Easy Speak" located so all teachers can see the screen
- 1 "Examples of Conditionals" Worksheet for each teacher

Explain the importance of the "Wizard's Workshop" activity to the teachers (cf. the Overview for Master Teachers above).

Choose one conditional Input-Output machine that the teachers are familiar with. Demonstrate the use of Easy Speak to create this machine. If you cannot place a computer so all the teachers can observe it, then you can have the teachers gather in groups of 4 around computers and simultaneously create the machine.

Be sure all teachers know that if all inputs are treated alike by the machine, they only use one condition, and that is:

CONDITION: ALWAYS

Easy Speak

Time 20 minutes

Materials
1 PET computer loaded with "Easy Speak" for each pair of teachers
(If you don't have enough computers, teachers can work in fours.)

If teachers are working in pairs, have them create a machine for another group. Then they can guess the rule for the second group's machine. If teachers are working in fours, one pair can create a machine for the other pair, and then trade places. Some teachers may prefer to create sevberal machines for themselves rather than for other groups. They can learn a lot by seeing the consequences of their creation.

Summary

Time 5 minutes

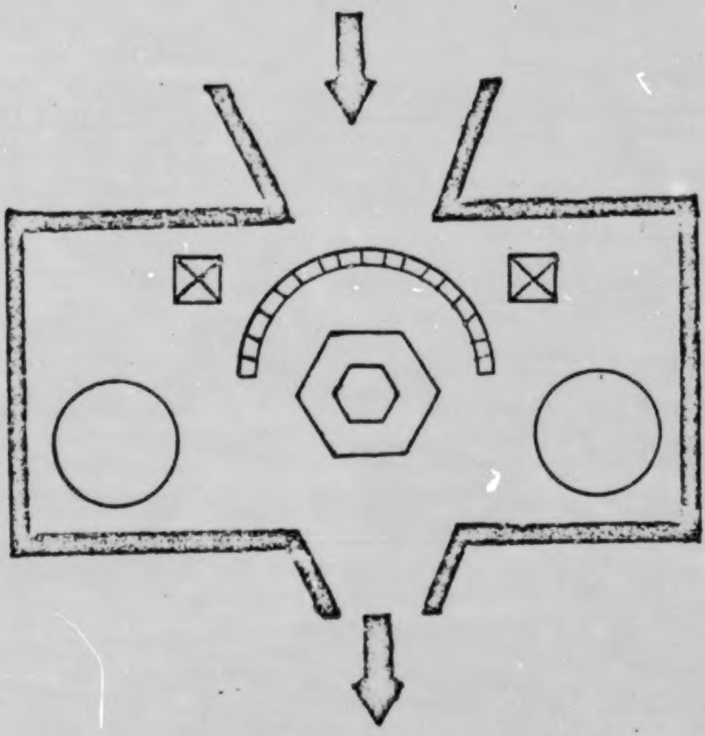
Materials None

Solicit opinions from the teachers about the usefulness of this unit for algebra.

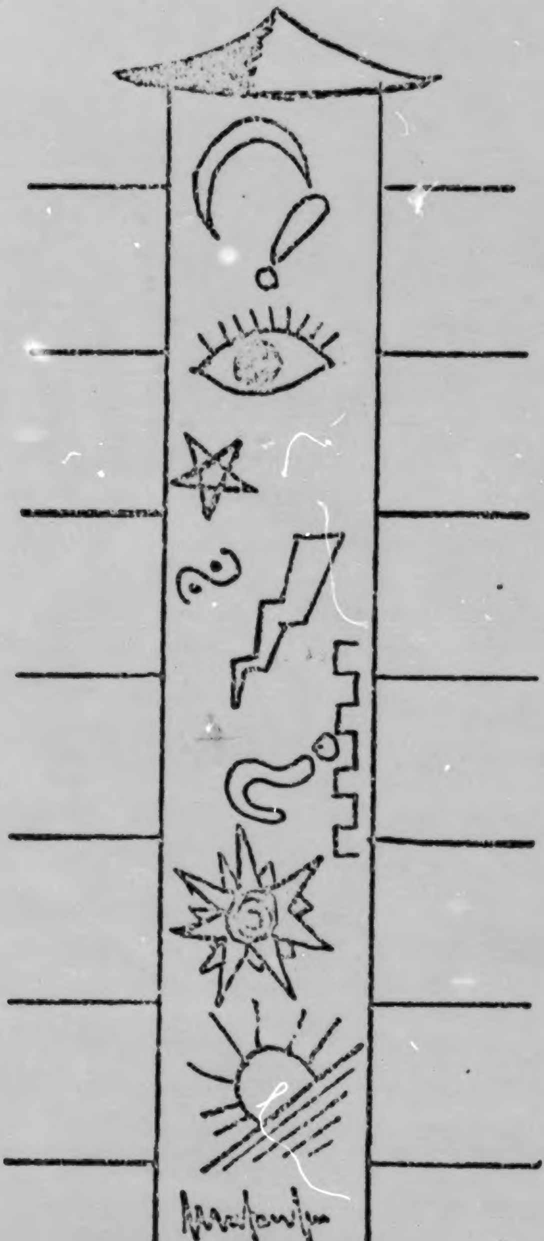
Discuss the process of guessing and finding patterns. Find out if the teachers were uncomfortable with this process. Discuss ways to make studdents feel more comfortable.

Ask the teachers once more to discuss their feelings about group work.

INPUT-OUTPUT MACHINE



INPUT	OUTPUT



MYSTERY
TOWER

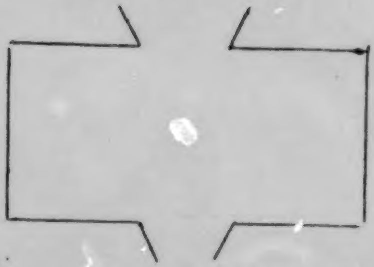
____

____

____

____

OTHER MACHINES



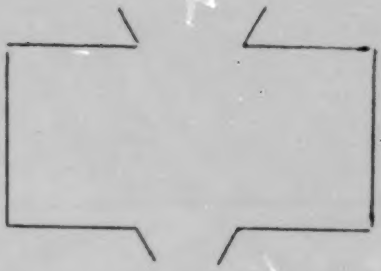
IN	OUT

____

____

____

____



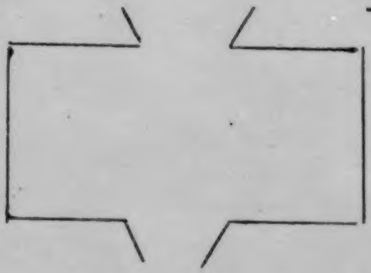
IN	OUT

____

____

____

____



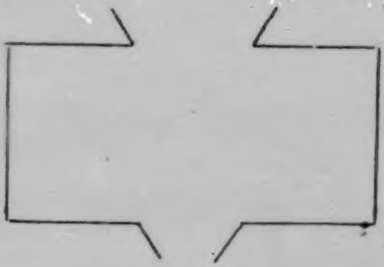
IN	OUT

____

____

____

____



IN	OUT

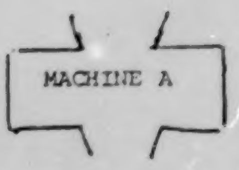
____

____

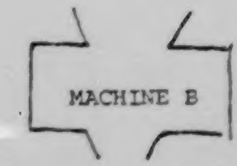
____

____

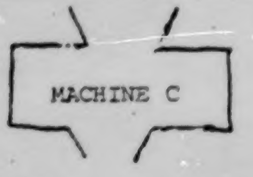
MYSTERY MACHINES



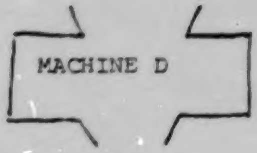
IN	OUT
1.	7
2	9
3	11
4	13
5	15
6	17



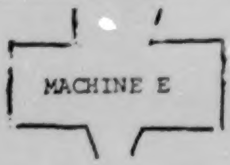
IN	OUT
1	2
2	22
3	6
4	44
5	10
6	66



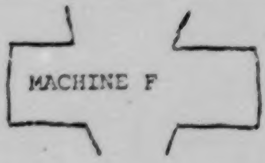
IN	OUT
1	2
2	4
3	6
4	24
5	30
6	36



IN	OUT
7	5
8	5
9	5
10	13
11	13
12	13



IN	OUT
5	15
6	14
7	13
8	12
9	11
10	10



IN	OUT
3	8
4	11
5	14
6	17
7	20
8	23

EXAMPLES OF CONDITIONALS

Listed below are six sets of conditional statements in EASY SPEAK and six tables. In the spaces below, write the letter of the table that matches the numbered statements. One of the six does not match.

I.____________ III.____________ V.____________

II.____________ IV.____________ VI.____________

I. 1. CONDITION: INPUT > 6
OUTPUT= 20-INPUT
2. CONDITION: INPUT ≤ 6
OUTPUT= 2*INPUT-1

II. 1. CONDITION: EVEN(INPUT)
OUTPUT= 8
2. CONDITION: ODD(INPUT)
OUTPUT= INPUT+5

III. 1. CONDITION: FACT(3,INPUT)
OUTPUT= INPUT*INPUT
2. CONDITION: NOT FACT(3, INPUT)
OUTPUT= 3*INPUT

IV. 1. CONDITION: EVEN(INPUT)
OUTPUT= INPUT-1
2. CONDITION: ODD(INPUT)
OUTPUT= 13-INPUT

V. 1. CONDITION: INPUT < 6
OUTPUT= 3*INPUT
2. CONDITION: INPUT ≥ 6
OUTPUT= INPUT*INPUT

VI. 1. CONDITION: FACT(5,INPUT)
OUTPUT= 2*INPUT+2
2. CONDITION: NOT(FACT(5,INPUT))
OUTPUT= INPUT+7

A		B		C		D		E		F	
INPUT	OUTPUT	INPUT	OUTPUT	INPUT	OUTPUT	INPUT	OUTPUT	INPUT	OUTPUT	INPUT	OUTPUT
3	5	1	3	2	8	4	8	2	1	1	8
4	7	2	6	3	8	5	10	6	5	2	9
5	9	3	9	4	8	6	12	1	12	3	10
6	11	4	12	5	10	7	14	4	3	4	11
7	13	5	15	6	8	8	16	5	8	5	12
8	12	6	36	7	12	9	13	9	4	6	13
9	11	7	21	8	8	10	14	3	10	7	14
10	10	8	24	9	14	11	15	8	7	8	15
11	9	9	81	10	8	12	16	7	6	9	16

WIZARD'S WORKSHOP

EXPERIMENT TITLE

TABLE

DESCRIPTION
OF TABLE

*CRITERIA QUESTION
FOR__________ YOU GET__________

EXPERIMENT TITLE

TABLE

DESCRIPTION
OF TABLE

*CRITERIA QUESTION
FOR__________ YOU GET__________

EXPERIMENT TITLE

TABLE

DESCRIPTION
OF TABLE

*CRITERIA QUESTION
FOR__________ YOU GET__________

EXPERIMENT TITLE

TABLE

DESCRIPTION
OF TABLE

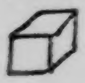
*CRITERIA QUESTION
FOR__________ YOU GET__________

WIZARD'S WORKSHOP

CUBE TOWER PAINTING

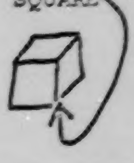
MATERIALS:
10 or 12 cubes

With the first tower there are 5 squares to paint.

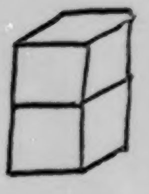


(4 sides and the top)

DON'T
COUNT
THE
BOTTOM
SQUARE



With the second tower there are 9 squares to paint.



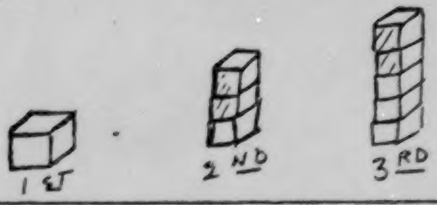
How many squares for the 3rd tower? 4th? Make a table.

	SQUARES
1	5
2	9
3	

*Suppose you built the 99th tower.
Suppose you had to paint each square on the tower.
How many squares would you have to paint?

FOR MASTER WIZARDS

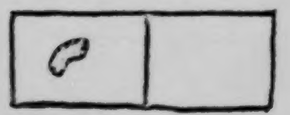
The first tower is the same, but for each succeeding tower you add two cubes to be painted.



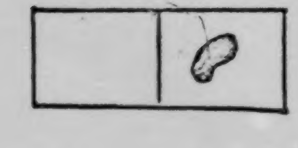
WIZARD'S WORKSHOP

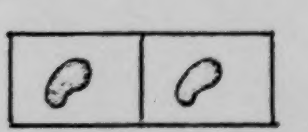
BEANS AND WAYS

MATERIALS:
10 or 12 beans
(or counters)
2 cups or squares
drawn on paper

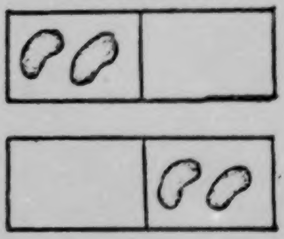


With just 1 bean, there are 2 ways to put it into the containers.





With 2 beans, you can put them into the containers 3 different ways.



How many ways for 3 beans? 4? Make a table.

BEANS	WAYS
1	2
2	3
3	

*Suppose you had 50 beans. How many ways could you put the 50 beans in the containers?

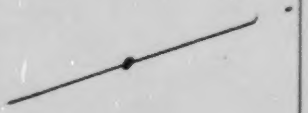
FOR MASTER WIZARDS

All is the same, except that there are three containers.

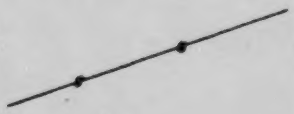
WIZARD'S WORKSHOP

SECTIONS ON A LINE

With one point, you would have 2 sections.



With 2 points, there would be 3 sections.

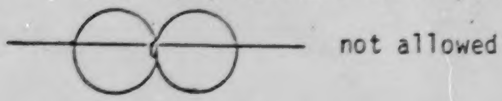


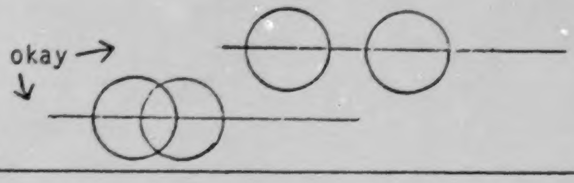
Continue making points and counting sections.

POINTS	SECTIONS
1	2
2	3
3	

*If you put 20 points on a line segment, how many sections would you count?

FOR MASTER WIZARDS
Instead of points, you draw circles (the sides don't touch).
How many sections would you count?





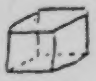
WIZARD'S WORKSHOP

STAMPING RODS

MATERIALS
1 rod of each color

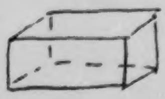
Suppose the white Cuisenaire rod were a rubber stamp. It would stamp a shape like this: ☐ How many stamps would it take to cover each of the other rods?

The white rod takes 6 stamps.



(Don't forget the bottom!)

The red rod takes 10 stamps.

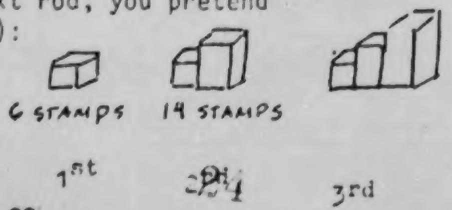


CONTINUE THE STAMPING.

ROD	STAMPS
1-white	6
2-red	10
3-light gr.	
4-purple	
5-yellow	
6-dark gr.	
7-black	
8-brown	
9-blue	
10-orange	

*Suppose you had a rod 32 units long; how many stamps?

FOR MASTER WIZARDS:
Instead of starting with the next rod, you pretend to glue it to the previous rod (s):

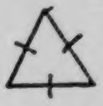


...etc.

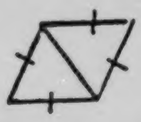
WIZARD'S WORKSHOP

A ROW OF TRIANGLES

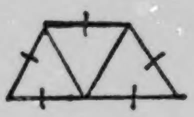
WITH 1 TRIANGLE, THE PERIMETER IS 3 UNITS.



WITH 2 TRIANGLES, THE PERIMETER IS 4 UNITS.

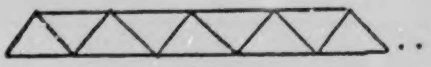


WITH 3 TRIANGLES, THE PERIMETER IS 5 UNITS.



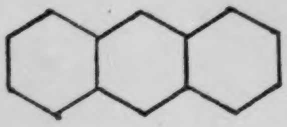
CONTINUE THE EXPERIMENT.

Tri-angles	peri-meter
1	3
2	4
3	
4	

*If you lined up 100 equilateral triangles in a row what would the perimeter measure? ()

FOR MASTER WIZARDS:

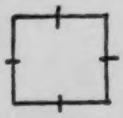
Instead of triangles, use regular hexagons.



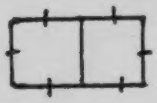
WIZARD'S WORKSHOP

A ROW OF SQUARES

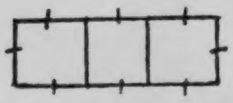
WITH 1 SQUARE, THE PERIMETER IS 4 UNITS.



WITH 2 SQUARES, THE PERIMETER IS 6 UNITS.

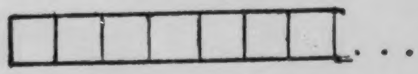


WITH 3 SQUARES, THE PERIMETER IS 8 UNITS.



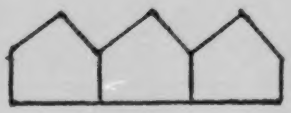
CONTINUE THE EXPERIMENT.

Squares	Perimeter
1	4
2	6
3	
4	

*If you lined up 100 squares in a row (), what would the perimeter measure?

FOR MASTER WIZARDS:

Instead of squares, use pentagons.

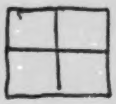


WIZARD'S WORKSHOP

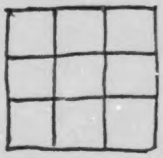
SQUARES FROM SQUARES

For a square with side 1, the perimeter is 4.

For a side of 2, the perimeter is 8.



For a side of 3, it's 12.



Continue the experiment.

LENGTH OF SIDE	PERIMETER
1	4
2	8
3	
4	

•FOR A SQUARE OF SIDE 47, WHAT IS THE PERIMETER?

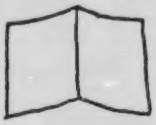
FOR MASTER WIZARDS

INSTEAD OF FINDING THE PERIMETER FOR EACH SIZE SQUARE, FIND THE AREA.

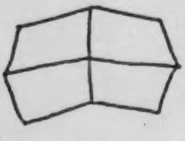
WIZARD'S WORKSHOP

PAPER FOLDING

With 1 fold, you would have 2 sections.



With 2 folds, you'd have 4 sections.



(REFOLD EACH TIME)

Make a table. Continue the folding.

FOLDS	SECTIONS
1	2
2	4

•IF IT WERE POSSIBLE TO FOLD THE PAPER 11 TIMES, HOW MANY SECTIONS WOULD YOU HAVE?

EASY SPEAK SUMMARY

+	addition	=	equals
-	subtraction	<	less than
*	multiplication	>	greater than
/	division	<=	less than or equal to
↑	exponentiation	>=	greater than or equal to
		< >	not equal to

ODD	ODD (INPUT)
EVEN	EVEN (INPUT)
ALWAYS	Is always true.
NEVER	Is never true.
FACT	FACT(5,INPUT) Will be true if 5 is a factor of the input.
NOT	NOT(INPUT < 10) Change the truth value of the statement.
AND	(5,INPUT) AND (EVEN(INPUT))
OR	(EVEN(INPUT)) OR (5 < INPUT)
SQR	SQR(9) SQR(INPUT) SQR(9) gives 3, the square root of 9.
INT	INT(4.2) INT(INPUT/5) INT(4.2) gives the value 4
RMD	RMD(8,3) RMD(8,3) gives 2, the remainder of 8÷3.
MAXIMUM	MAXIMUM(INPUT,10)
MINIMUM	MINIMUM(INPUT*3,20)
LCM	LCM(4,6) LCM(INPUT,24) LCM(4,6) gives 12, the least common multiple of 4 and 6.
GCD	GCD(INPUT,5) GCD(20,8) GCD(20,8) gives 4, the greatest common divisor of 20 and 8.
RANDOM	RANDOM(2,10) RANDOM(INPUT,20) RANDOM(2,10) will randomly pick either 2, 3, 4, 5, 6, 7, 8, 9, or 10.

STRATEGIES

Prerequisite Input-Output Unit

Time 2 hours

Materials
- 2 small objects (paper clips, toothpicks, etc.) for every 4 teachers
- 12 large objects
- 12 small objects (paper clips, toothpicks) per pair of teachers
- 1 PET computer per 3 or 4 teachers
- "Guess My Strategy" computer program
- 1 "Guess My Strategy" Worksheet per teacher
- "Nim Speak" computer program
- 1 "Nim Speak" Worksheet per teacher
- 1 "Easy Speak Summary" Sheet per teacher

SUGGESTED TIME FRAME

Time	Activity
5 min	Introduction
10 min	The Bone Game
20 min	Basic Nim
35 min	Guess My Strategy
45 min	Nim Speak
5 min	Summary

OVERVIEW FOR MASTER TEACHER

The Strategies Unit builds on the skills learned in the Input-Output unit. Thus, teachers should have worked with the Input-Output Unit before learning about the Strategies Unit. Just as with the prerequisite unit, the Strategies Unit motivates students to find patterns and to use algebra to express those patterns. You may wish to review the "Introduction for Master Teachers" in the Input-Output section of this guide before proceeding with this new unit.

Most of the work in this unit concerns finding and expressing strategies for a version of the game of Nim. Although this game has a "perfect" strategy (ie. a way of playing where one can always win if given the choice of being the first or second player), the emphasis in the unit is not to discover this one winning strategy. Rather, the unit focuses on discovering and expressing the strategies used by other players and on inventing and expressing strategies of one's own. This focus allows all students to participate in the unit at their own level in a creative way and does not restrict the activities to producing one right answer.

Adults often have a greater tendency than younger students to search out a best strategy, and they find it difficult to focus on discovering their opponent's strategy rather than on beating their opponent. Therefore, it is important in a workshop to interest teachers in the challenge of discovering strategies. We have found that once a teacher is interested in discovering strategies, his or her students have no problem focusing on this activity.

Introduction

Time 5 minutes

Materials None

You should emphasize two points in the introduction:

> This unit builds on the skills developed in the Input-Output unit.
>
> The focus in this unit is not to find the one best strategy but to discover and express a variety of strategies.

Both of these points were discussed above.

The Bone Game

Time 10 minutes

Materials
2 small objects per every 4 teachers (paper clip, toothpick, etc.)

Show the teachers two small objects (bones). Hide them in your fists. Ask them to guess if (a) there is one in each fist, (b) both in your right fist, or (c) both in your left fist.

Tell them this is a variation of an old Native American game. Have the teachers pair off, and ask each pair to play against another pair. They are to consult with their partners before hiding the bones and before guessing. One pair should hide the bones five times with the other pair guessing. The teams should continue playing, switching roles after each five times they play.

After the teachers have played for five minutes, stop them and discuss the strategies they used both for hiding and for guessing. Some teachers may consider their method too simple or too obvious to mention, so you may need to draw out their strategies.

This game introduces students to strategies, gives them confidence in their abilities to invent strategies, and starts them in expressing strategies.

Basic Nim

Time 20 minutes

Materials
- 12 large objects (books, blocks, etc.)
- 12 small objects (paper clips, toothpicks, etc.)
  for each pair of teachers

Put the 12 large objects in the front of the room so everyone can see them, or put 12 "X" marks on the chalkboard. Take turns with the class removing 1, 2, or 3 objects at a time. Let the class decide whether to go first or second. The one who takes the last object wins (unlike other versions of Nim).

Now have teachers play the game in pairs. After about 5 minutes of play, have each pair play against another pair. If some groups have found out how to win, have them vary the number of objects and the number they can take on a turn. For example, they could use 15 objects and take up to 5 objects on a turn.

Guess My Strategy

Time 35 minutes

Materials
- 1 PET computer for every 3 or 4 teachers,
  loaded with the "Guess My Strategy" program
- 1 Guess My Strategy Worksheet for each teacher

Tell the teachers that now they have explored winning at Nim. Next, they will meet 6 Nim players in the "Guess My Strategy" computer program. Their goal is not to beat these players; rather, it is to figure out their strategy. They will want to learn whether these players will go first or second (and under what circumstances) if they are given a choice. Next, they want to know how a player will play at any given stage of a game.

Note that the computer will choose different numbers of objects to start with and different maximums. Have one computer loaded with the program facing the class so that everyone can see its screen. Have the whole class play Zerox until everyone knows his strategy. Then have the class try to imitate his strategy by choosing the computer option, "B. Imitate a Program".

Make sure everyone understands that they are trying to discover the player's strategy.

Give each teacher a worksheet and have them work in threes or fours at a computer. They should play One-Track, Obsessed, or Very Cool. Once they think they know a player's strategy, they should try to imitate the player.

Nim Speak

Time 45 minutes

Materials
- 1 PET computer loaded with "Nim Speak" for every 2 to 4 teachers
- 1 "Nim Speak" Worksheet per teacher
- 1 "Easy Speak" Summary Sheet per teacher

Ask the teachers to describe the strategy that "Very Cool" used (ie., goes second if given a choice and always takes one until he can win in one move). Tell them they will now teach the computer to play Nim as Very Cool does.

They should choose "A" from the menu ("Program My Strategy"). They can choose a number (from 12 to 20) of starting matches which will be used in all games, or they can type "START". If they choose the latter, the computer will choose a random number between 12 and 20 to start each game. Most students should begin by using the same number for each game, but the teachers should type "START". Similarly, they should type "MAX" for the maximum matches to take on a move, while their students will begin with a fixed number between 2 and 6.

The teachers will use the Easy Speak language plus 3 variables: Start, Max, and Left (the number of matches left in a game) to express a strategy.

Next, the computer wants to know the condition for going first (if given a choice). In the case of Very Cool, it is NEVER. Next, they must figure out how to tell the computer to play as Very Cool does. They should come up with something like:

```
CONDITION:  LEFT>MAX
TAKE:  1

CONDITION:  LEFT<=MAX
TAKE:  LEFT
```

Now have the computer play Nim using the strategy (by choosing "E" from the menu). Tell the teachers that the computer must check all their statements for a conflict before playing. They will see a flashing "T" (for "thinking") while it checks. Show them how to edit or change their strategy.

Now let the teachers invent strategies using the Nim Speak program. Let them try to guess each other's strategies.

Summary

Time 5 minutes

Materials None

Review the purposes of the units: to find patterns and to use algebra to express patterns. Discuss any questions the teachers have or any problems they might anticipate having with the students.

GUESS MY STRATEGY WORKSHEET

Be sure to tell the PET you want to (A), Play With A Program. You can choose One-Track, Obsessed, or Very Cool.

Play several times with the same program until you think you know its strategy.

1. Name of Program________________________

2. Describe your program's strategy.

3. How does your program feel about going first?

4. Do you think your program is a good player? Why?

See if you can imitate your program!

Turn page over to record games.

33

Game 1

Start With:____________

Max to Burn:____________

If your program had a choice, did it choose to go FIRST or SECOND (circle one)?

PLAYER	BURNT	NO. LEFT

Game 2

Start With:____________

Max to Burn:____________

If your program had a choice, did it choose to go FIRST or SECOND (circle one)?

PLAYER	BURNT	NO. LEFT

Game 3

Start With:

Max to Burn:

If your program had a choice, did it choose to go FIRST or SECOND (circle one)?

PLAYER	BURNT	NO. LEFT

Game 4

Start With:

Max to Burn:

If your program had a choice, did it choose to go FIRST or SECOND (circle one)?

PLAYER	BURNT	NO. LEFT

Nim Speak Sheet

Programmer:

1. Start with:

2. Max to Take:

3. I Should Go First If

4. If

Then I Take

5. If

Then I Take

6. If

Then I Take

7. If

Then I Take

8. If

Then I Take

9. If

Then I Take

10. If

Then I Take

11. If

Then I Take

12. If

Then I Take

13. If

Then I Take

EASY SPEAK SUMMARY

+	addition	=	equals
-	subtraction	<	less than
*	multiplication	>	greater than
/	division	<=	less than or equal to
↑	exponentiation	>=	greater than or equal to
		< >	not equal to

ODD	ODD (INPUT)
EVEN	EVEN (INPUT)
ALWAYS	Is always true.
NEVER	Is never true.
FACT	FACT(5,INPUT) Will be true if 5 is a factor of the input.
NOT	NOT(INPUT < 10) Change the truth value of the statement.
AND	(5,INPUT) AND (EVEN(INPUT))
OR	(EVEN(INPUT)) OR (5 < INPUT)
SQR	SQR(9) SQR(INPUT) SQR(9) gives 3, the square root of 9.
INT	INT(4.2) INT(INPUT/5) INT(4.2) gives the value 4
RMD	RMD(8,3) RMD(8,3) gives 2, the remainder of 8÷3.
MAXIMUM	MAXIMUM(INPUT,10)
MINIMUM	MINIMUM(INPUT*3,20).
LCM	LCM(4,6) LCM(INPUT,24) LCM(4,6) gives 12, the least common multiple of 4 and 6.
GCD	GCD(INPUT,5) GCD(20,8) GCD(20,8) gives 4, the greatest common divisor of 20 and 8.
RANDOM	RANDOM(2,10) RANDOM(INPUT,20) RANDOM(2,10) will randomly pick either 2, 3, 4, 5, 6, 7, 8, 9, or 10.

BUSINESS

Prerequisite Input-Output Unit

Time 2 hours

Materials

1 "What's Ice Cream Worth To You" worksheet per teacher
1 "Lemonade, Pencils and Apple Pie" worksheet per teacher
1 "The Typist" worksheet per 4 teachers
1 "The Editor" worksheet per 4 teachers
1 "The Pilot" worksheet per 4 teachers
1 "Making Worksheets For Other Groups" per 4 teachers
"Tutoring Service" computer program
1 "Tutoring Service" worksheet per 3 teachers
"At Your Service" computer program
1 "At Your Service" worksheet per 3 teachers
1 PET computer per 3 teachers

Suggested Time Frame

Time	Activity
5 min	Introduction
15 min	What's Ice Cream Worth To You?
20 min	Lemonade, Pencils, and Apple Pie
20 min	The Computer Programmer
15 min	Practice Businesses
15 min	Tutoring Service
25 min	At Your Service
5 min	Summary

Overview for Master Teacher

The Business Unit builds on skills learned in the Input-Output Unit. The input-output machines used in this unit, however, are all of the form Output=A-B*Input, where A and B are numbers. We have learned from experience that the rule for this sort of machine (where the output is obtained by subtracting the input or a multiple of the input from some number) is difficult for teachers as well as students. Thus, the first two activities in the Unit are devoted to developing skill in finding these rules. Teachers should be cautioned to not go on with the rest of the unit until their students are comfortable with finding these rules. Similarly, if the teachers you are working with have very weak mathematical backgrounds, you may need to spend more time on the first two activities.

As in the case of the Input-Output Unit, this unit is designed to motivate students to find patterns and to express those patterns using algebra. You may want to review the "Introduction for Master Teachers" in the Input-Output section of this guide before proceeding with this new unit.

The Business Unit, unlike the Input-Output Unit, is concerned with finding patterns and algebraic rules to describe real world situations, namely, the relation of Hours Worked (or demand) to the hourly Rate Charged. In conducting a business, people want to know what hourly rate they should charge. If their rate is too high, they won't get enough customers to make much money. If their rate is too low, although they may get plenty of work, they may not make much money since they are charging so little.

In order to set the optimum prices for services and for products, businesses often need to have an algebraic rule which approximates the relation of prices to demand. One can't use a neat algebraic formula to describe the exact relationship, but one can find a nice formula that comes close. These formulas are called Mathematical Models. In college business and statistics courses, ways of finding Mathematical Models for real situations are studied. In this unit, we will only look at the neat formulas (or mathematical models) themselves. The teachers and their students should understand that we are studying "phoney" or idealized businesses and that the real world doesn't fit so nicely into mathematical formulas. However, there is real value in studying idealized businesses since they are used in real life to make business predictions and decisions.

If any of the teachers you are working with teach algebra or pre-algebra, you should be sure to point out the significance of the numbers A and B in the formulas:

$$\text{Output} = A-B^{*}\text{Input}.$$

In usual algebraic notation, the formulas we use in this unit are written:

$$y=A-Bx$$

The graphs of the equations are straight lines, and the number A is the y-intercept, while B is the slope of the line.

Introduction

Time 5 minutes

Materials None

You should make three points in the introduction:

> Teachers can use this unit without prior knowledge of business mathematics.
>
> The input-output rules which occur in this unit may be difficult for students.
>
> The businesses studied in this unit are simulations of real businesses (or idealizations), but simulations are often useful.

You Can Do It

You might ask the teachers if they feel uncomfortable with this subject matter and let them express any fears they might have. You can reassure them that all they will need to know is certain kinds of input-output rules which they will learn about in this session. They already know what they need to know about business, ie. if you charge more, you'll generally sell less.

Difficult Rules

Even students who did well with the Input-Output rules may need some time to become comfortable with the rules in this unit. Thus, the teachers will need to spend sufficient time on the early activities. They should be prepared to spend an extra day on the second activity.

Use of Simulations

Explain the need to work with simulation businesses, as described in the "Introduction for Master Teachers."

What's Ice Cream Worth To You

Time 15 minutes

Materials
1 "What's Ice Cream Worth to You" worksheet per teacher

You may want to change the product duscussed from ice cream cones to a product relevant to adults. Sirloin steaks or cocktails are possible subjects.

Tell the teachers the purpose of this activity is to make the relationship of price to demand relevant to students.

Proceed through the activity as it is described in the Teacher's Guide.

Lemonade, Pencils, and Apple Pie

Time 20 minutes

Materials
1 "Lemonade, Pencils, and Apple Pie" worksheet per student

Have the teachers work in groups of three or four on the worksheet for about 15 minutes. You may need to help some groups find the Zero Price Demand in Problem 2 by asking them to follow the pattern to guess at number sold for 10c and then for 0c. You may need to give teachers more time if they aren't comfortable finding rules.

In the last five minutes, conduct the discussion suggested in the Teacher's Guide. Also discuss the role of the number the price is multiplied by. (cf. homework discussion at the beginning of "The Computer Programmer" activity in the Teacher's Guide.) If no one mentions the mathematical terms "y-intercept" and "slope", you might point out their relevance.

Mention that there is a homework sheet for students.

The Computer Programmer

Time 20 minutes

Materials
1 "The Typist" worksheet for each teacher

Caution the teachers not to proceed with this activity until their students are comfortable finding the input-output rules. They may need to make up another worksheet.

Follow the discussion of "The Computer Programmer" in the Teacher's Guide. Then work through "The Typist" worksheet with the teachers. See if they can explain how to find the real Zero Price Demand for the Typist.

Practice Businesses

Time 15 minutes

Materials
1 "The Editor" worksheet per 4 teachers
1 "The Pilot" worksheet per 4 teachers
1 "Making Worksheets for Other Groups" worksheet per 4 teachers

Let teachers work in groups of four on the worksheets. Leave some time to discuss the best price to charge (cf. Teacher's Guide discussion for this activity).

Tutoring Service

Time 15 minutes

Materials
- 1 PET computer loaded with Tutoring Service per group of 3 teachers
- 1 "Tutoring Service" worksheet per 3 teachers

Let the teachers work in groups of 3 with the program. Tell them they will need to remind students to record data on their worksheets and to find the rule for one subject before moving on to another one. As soon as the teachers finish with the program, load "At Your Service" into the computer.

At Your Service

Time 25 minutes

Materials
- 1 PET computer loaded with "At Your Service" per 3 teachers

Tell the teachers that this activity should help their students see the practical results of algebraic formulas. They should not expect their students to come up with realistic businesses. The purpose of this activity is to allow students to experiment with various formulas.

Demonstrate "At Your Service" on one computer as described in the Teacher's Guide. Use the variable AD with the teachers, but tell them that they may not wish to use it with their students.

Then have the teachers invent their own simulations in groups of 3. Encourage them to try different formulas to see how thier simulation changes.

Summary

Time 5 minutes

Materials None

Go over the three points in the introduction:

You Can Do It

Ask the teachers if they feel comfortable using this unit with students. If they don't, another teacher might volunteer to help them go over some activities they find difficult.

Difficult Rules

Remind them not to go to "The Computer Programmer" activity before students are comfortable finding the rules. You might discuss ways to help students find the rules.

Use Cf Simulations

Ask the teachers to discuss why simulations are useful.

What's Ice Cream Worth To You?

The Sweetcooks are about to open their own ice cream store featuring their homemade ice cream. They need some data to set their prices for ice cream cones. For each of the prices listed below, write how many cones you would buy a day at that price.

Price of a Cone	Number You'd Eat a DAY
0 cents	
50 cents	
100 cents	
150 cents	
200 cents	
250 cents	

Name____________________

LEMONADE, PENCILS, AND APPLE PIE

1. The chart below shows sales of cups of lemonade at different prices.

Price of Lemonade	No. of Cups Sold
0	70
10¢	60
20¢	50
30¢	40
40¢	30
50¢	20
60¢	10

What is the Zero Price Demand?

Answer:____________________

Find a rule for No. Sold in terms of Price:

No. Sold=____________________

3. The chart below shows sales of pencils at different prices.

Price of a Pencil	No. of Pencils Sold
0	10
1	9½
2	9
3	8½
4	8
5	7½
6	7

What is the Zero Price Demand?

Answer:____________________

Find a rule for No. Sold in terms of Price:

No. Sold=____________________

2. The chart below shows sales of apple pies at different prices.

Price of Apple Pie	No. of Pies Sold
0	40
$1	35
$2	30
$3	25
$4	20
$5	15
$6	10

What is the Zero Price Demand?

Answer:____________________

Find a rule for No. Sold in terms of Price:

No. Sold=____________________

4. For a certain Taco Stand, the rule for number of tacos sold in terms of price is
   No. Sold= 420-Price*3.
   What is the Zero Price Demand?

Answer:____________________

Fill in the chart for the Taco Stand:

Price of a Taco	No. of Tacos Sold
40	______
60	______
90	______
______	120
140	______

(continued)

The chart below shows sales of a brand of blue jeans at different prices.

Price of Blue Jeans	No. of Blue Jeans Sold
$5	125
$10	100
$15	75
$20	50
$25	25
$30	0

What is the Zero Price Demand?

Answer: ____________________

Find a rule for No. Sold in terms of Price:

No. Sold= ____________________

6. Make a business with a rule and a chart. Fill in the chart below and see if another group can find your Zero Price Demand and your rule.

____

The Typist

Name____________________

The table below shows the number of hours a typist will work a week depending on the hourly rate he charges. Fill in the column for his Weekly Earnings, then answer the questions below.

RATE	HOURS WORKED	WEEKLY EARNINGS
0	40	
1	40	
2	40	
3	40	
4	40	
5	40	
6	40	
7	30	
8	20	
9	10	
10	0	
11	0	
12	0	

1. What do you think are the maximum hours a week the Typist has chosen to work?

2. What's the rate the Typist will charge when he begins to get no business?

3. Try to write a rule for the Hours Worked in terms of the Rate the Typist charges. (It may have more than one part.)

4. What rate should the Typist charge if he wants to maximize his earnings?

Group Names 1.____________________

2.____________________

3.____________________

4.____________________

The Editor

The table below shows the number of hours an editor will work a week depending on the hourly rate he charges. Fill in the column for his Weekly Earnings, then answer the questions below.

RATE	HOURS WORKED	WEEKLY EARNINGS
0	40	
5	30	
10	20	
15	10	
20	0	
25	0	
30	0	
35	0	

1. What do you think are the maximum hours a week the Editor has chosen to work?

2. What's the rate the Editor will charge when he begins to get no business?

3. Try to write a rule for the Hours Worked in terms of the Rate the Editor charges. (It may have more than one part.)

4. What rate should the Editor charge if he wants to maximize his earnings?

Group names________________________

____

____

____

THE PILOT

The table below shows the number of hours a pilot will work a week depending on the hourly rate she charges. Fill in the column for her Weekly Earnings, then answer the questions below.

RATE	HOURS WORKED	WEEKLY EARNINGS
10	20	
15	20	
20	20	
25	17½	
30	15	
35	12½	
40	10	
45	7½	
50	5	
55	2½	
60	0	
65	0	

1. What do you think are the maximum hours a week the Pilot has chosen to work?

2. What's the rate the Pilot will charge when she begins to get no business?

3. Try to write a rule for the Hours Worked in terms of the Rate the Pilot charges. (It may have more than one part.)

4. What rate should the Pilot charge if she wants to maximize her earnings?

MAKING WORKSHEETS FOR OTHER GROUPS

Directions (Below each step for writing your worksheet is the step followed in making The Typist Worksheet.)

1. Choose a profession for your worker.
   Example:
   Typist

2. Choose a one-part rule that connects Hours Worked with Rate.
   Example:
   Hours = 100 - 10 * Rate

3. Fill in a table for your rule.

   Example:

RATE	HOURS WORKED
0	100
1	90
2	80
3	70
4	60
5	50
6	40
7	30
8	20
9	10
10	0
11	0

4. Choose a maximum number of hours for your worker to work.
   Example:
   40 hours

5. Change your table so no hours worked are more than your maximum.

   Example:

RATE	HOURS WORKED
0	~~100~~ 40
1	~~90~~ 40
2	~~80~~ 40
3	~~70~~ 40
4	~~60~~ 40
5	~~50~~ 40
6	40
7	30
8	20
9	10
10	0
11	0

6. Make up some questions about your worker for another group.
   Example:
   See The Typist worksheet.

7. Make a worksheet that includes the changed table and your questions.
   Example:
   See The Typist worksheet.

(continued)

8. Exchange worksheets with another group.
   Example:
      You can do this yourself.

Group Names:

1.____________________

2.____________________

3.____________________

4.____________________

TUTORING SERVICE WORKSHEET

1. Maximum Hours you are willing to work a week:________

2. Make a table of the hours you worked and earnings for each rate. (Type Shift and @ if you don't want to wait for results.)

RATE	HOURS WORKED	EARNINGS

3. Try to write a rule for the Hours Worked in terms of the Rate you charge:

4. What Rate should you charge if you want to maximize your earnings?

Group Names:____________________

____

____

____

AT YOUR SERVICE WORKSHEET

Part I

1. YOUR BUSINESS' NAME IS:
2. THE MOST HOURS A PLAYER MAY WORK IS:
3. CAN PLAYERS ADVERTISE? (Y or N)
4. THE HOURS OF WORK A PLAYER GETS=

Part II

Before trying your simulation on the computer, predict:

1. What is the Zero Price Demand?
   (If you are using AD, answer this for several values of AD).

2. What is the best RATE (or combination of RATE and AD) to charge to make the most money?

3. How much money will you make in that situation?

52

Part III

Run your simulation on the computer. Try different rates and amounts of advertising. Fill in some values on the chart.

RATE	AD	Hours Worked	Amount Earned

1. What is your Zero Price Demand?
   (If you used AD, answer for several values of AD.)

2. What is the best RATE (or combination of RATE and AD) to charge to make the most money?

3. How much money do you make in that situation?

SAMPLING UNIT

Time 2 hours, 30 minutes or 1 hour, 45 minutes

Materials

Copy of bags and worksheets For each Variation On Six experiment for every six teachers
6 pieces of long graph paper prepared for the six experiments
1 Variation On Six Discussion Sheet for each teacher
1 sack with 35 wooden cubes (14, 8, 3 of three different colors)
1 Beans In The Bag Discussion Sheet for each teacher
1 pound white beans
3 pounds brown beans
1 large paper sack
1 large sheet graph paper prepared for Bean Population
1 16K PET computer for each three teachers
"Guess My Bag" computer program
1 1-4 slip of paper for each teacher
1 large sheet of graph paper prepared for "Circle A Number"
"Prime Time" computer program
1 Program Schedule Worksheet per group of 3 or 4
1 Network Rating Report per group of 3 or 4
1 Currently Watching Research Recording Sheet per group of 3 or 4
1 People's Preference Research Recording Sheet per group of 3 or 4

Suggested Time Frame

Time	Activity
5 min	Introduction
20 min	Variations on Six
15 min	Cubes and Beans in the Bag
15 min	Guess My Bag
10 min	Circle a Number
45 min	Prime Time
5 min	Network Prime Time
5 min	Summary

Total: 2 hours

Overview for Master Teacher

The Sampling Unit is designed to have students make inturtive decisions on the basis of samples. In the way statistics is traditionally taught, students have little time to experience making such decisions. They are rushed into using formulas concerning the appropriate size of samples, and the corresponding confidence one can have in decisions based on samples before they have built up an intuition about these matters. Such an intuition can be developed best by actually sampling a population, making a guess or a prediction based on the sample, and seeing how close the prediction comes to reality. Computers can help in developing this intuition in two ways:

1. Eliminating the tedium.

Students need the experience of making and checking many predictions, but they do not need to draw and count objects more than a few times. In programs such as "Guess My Bag", the computer can perform the tedious tasks of drawing and counting, freeing the students to make decisions.

2. Creating Interesting Realistic Situations

The computer can simulate real situations for students where meaningful decisions (meaningful for the student) are based on samples. The program "Prime Time" allows the student to make decisions about scheduling television shows based on information drawn from samples.

This unit begins with the "Variations on Six" activity which develops the ideas of random selection and equally likely. These ideas allow us to predict properties of a population from examining random samples from the population. Students gain practice in making predictions in the next three activities. They begin to understand the importance of the sample size and the degree of confidence one can have in such predictions. In the last three activities, students apply their knowledge of samples to surveys of human opinion. Thus, they move from objective to subjective data.

Introduction

Time 5 minutes

Materials None

You should make three points in the introduction:

Statistics and sampling are important.

Traditional Statistics courses are hard, but if we prepare students properly, they can be easier.

Teachers can use this unit without prior knowledge of computers or statistics.

Sampling is Important

This point is best made by having the teachers suggest uses of samples in everyday life (e.g., political predictions, market surveys, quality control in factories, placing traffic signs, assessing damage from forest fires, etc.).

Statistics is Hard

Ask the teachers about their past experience, if any, in college Statistics courses. Most people find these courses full of formulas that have little meaning for them. Explain that in such courses there is little time to provide students with the experience to understand how such formulas are used and why they are important. Most students do not gain an understanding from being told; they must have the chance to do and to experiment. This unit is designed to give students understanding through doing things. Therefore, the teachers must allow their students to do and discuss the activities in this unit. Not all of their students will reach an understanding of all the principles in this unit, but they will begin to gain an understanding which we hope will be reinforced by future activities. Simply telling students the principles will do little to further understand and might confuse them.

They Can Do It

Many of your teachers will have had bad experiences in the past learning statistics. They may be afraid of trying this unit with students. Try to reassure them that students will enjoy the activities and that the teacher does not need to know all the answers before using this unit.

Variations on Six

Time 20 minutes

Materials

- 1 copy of Bags and Worksheets for each Variations on Six experiment for every six teachers
- pieces of long graph paper
- 1 "Discussion Sheet" for each teacher

This activity is designed to help students learn about "equally likely" events and random selection. Many students will believe that some numbers and students are lucky. They can only learn that the events in the experiments are equally likely by doing many experiments. Emphasize to the teachers that they must let their students do the experiments. Many teachers will not do this work with their class unless you do some of it with them.

Describe Activities

Describe the six activities to the teachers and show them the sample bagS you've made.

Do Activities

With the teachers working in pairs, have them do as many activities as time permits, and record their results on graph paper as described in the unit.

Discuss

Give each teacher a discussion sheet and briefly talk about each item.

Cubes And Beans in the Bag

Time 15 minutes

Materials
- 1 sack with 25 wooden cubes (14, 8, 3 of three different colors)
- 1 "Beans In The Bag Discussion Sheet" for each teacher
- 1 pound white beans
- 3 pounds brown beans
- 1 large paper sack
- 1 large sheet graph paper prepared for Bean Population

CUBES IN THE BAG

Go through the introduction from the Teacher's Guide for Cubes and Beans in the Bag, having teachers guess what the colors of the wooden cubes are.

BEANS IN THE BAG

Describe this activity and briefly discuss the Discussion Sheet.

BEAN POPULATION

Show the teachers the bag and the graph and explain the activity to them. This activity differs from the last one in that the size of the total population is unknown.

GUESS MY BAG

Time 15 minutes

Materials
  1 PET computer loaded with "Guess My Bag" Program for each three teachers

DESCRIBE ACTIVITY

Tell the teachers that the PET has a bag with 4 kinds of beans in it. It will show them 3 bar graphs, and one of the 3 graphs will fit its bag. Their job is to choose the right bar graph by sampling from the PET's bag. There are three levels of difficulty: 1 is easiest and 3 is hardest. Their score is figured by multiplying their difficulty level (1, 2, or 3) times 50 and subtracting the number of beans they sample.

PLAY

Have the teachers work through the program in groups of three.

LOAD "PRIME TIME"

Stop the teachers after 15 minutes and have them load "Prime Time" so the computer will be ready for the "Prime Time" activity. This will be a good opportunity to make sure everyone can load a program into the computer.

CIRCLE A NUMBER

Time 10 minutes

Materials
  1 1-4 slip of paper for each teacher
  1 large sheet of graph paper prepared for "Circle A Number"

TEACHERS CHOOSE A NUMBER

Give each teacher a slip of paper and have them circle a number.

GRAPH RESULTS (long form only)

Have the teachers make a bar graph by taping their slips of paper onto the graph paper over the number they choose.

DISCUSS ACTIVITY

Describe the follow-up homework activity that students will do. Make sure everyone understands objective and subjective data.

PRIME TIME

Time 45 minutes

Materials

- 1 PET computer loaded with "Prime Time" for each group of 3 or 4 teachers
- 1 "Program Schedule Worksheet" per group
- 1 "Network Rating Report" per group
- 1 "Currently Watching Research Recording Sheet" per group
- 1 "People's Preference Research Recording Sheet" per group

ACTIVITY

Present the Whole Class Introduction to the teachers from the Teacher's Guide. Let them work through the program. Some groups will need to be reminded of the time so they can finish the activity. Other groups will have time to work through the program with a second seed number.

NETWORK PRIME TIME

Time 5 minutes

Materials None

As students work through "Prime Time", they often lose sight of their sampling research data. The Network Prime Time gives the class a chance to review the data and to make a new decision.

Go over the use of the Network Prime Time program with the teachers. The instructions should be self-explanatory.

SUMMARY

Time 5 minutes

Materials None

Go over the three points made in the introduction: sampling is important; statistics is hard because it is introduced before students have enough intuition; and that the teachers are competent to teach this unit. Ask for feedback on the last two points.

VARIATIONS ON SIX WORKSHEET

NAME____________________________ NAME____________________________

EXPERIMENT #________

OUTCOME	TALLY
______________	
______________	
______________	
______________	
______________	
______________	

EXPERIMENT #________

OUTCOME	TALLY
______________	
______________	
______________	
______________	
______________	
______________	

EXPERIMENT #________

OUTCOME	TALLY
______________	
______________	
______________	
______________	
______________	
______________	

EXPERIMENT #________

OUTCOME	TALLY
______________	
______________	
______________	
______________	
______________	
______________	

VARIATIONS ON SIX

Student directions for six experiments

Teacher directions: Make three copies of this page, cut apart and tape to outside of appropriate bags.

EXPERIMENT #1 "DIE"

Shake die.
Roll die.
Record number that is rolled.
Do 25 times.

(contents: 1 die)

EXPERIMENT #2 "SPINNER"

Spin spinner.
Record letter the arrow points to.
Do 25 times.

(contents: Spinner divided into six equal parts and labeled "A,B,C,D,E,F")

EXPERIMENT #3 "Mini Deck"

Shuffle deck.
Choose one card without looking.
Record number on card.
Return card to deck.
Reshuffle.
Do 25 times.

(contents: Aces through 6's from a deck of cards)

EXPERIMENT #4 "Mini Red Deck"

Shuffle deck.
Choose one card without looking.
Record number on card.
Return card to deck.
Reshuffle.
Do 25 times.

(contents: red 8's through red Kings from a deck of cards)

EXPERIMENT #5 "BLOCKS"

Mix bag.
Draw out one block without looking.
Record color of block.
Return block to bag.
Re-mix bag.
Do 25 times.

(contents: six different colored blocks)

EXPERIMENT #6 "NAMES"

Mix bag.
Draw out card without looking.
Record name on card.
Return card to bag.
Re-mix.
Do 25 times.

(contents: 6 cards, each with a different student's name)

VARIATION ON SIX
DISCUSSION WORKSHEET

1. How are the six graphs the same? How are they different?

2. If the words and labels were removed, would it be very easy to tell which graph was which? Why or why not?

3. Are the heights of the columns about the same or do they vary? Why or why not?

4. Why was it important to shake the bag or shuffle the cards every time?

5. If we did each experiment 1000 times or a million times, could you predict what the results would be?

6. Were certain numbers or people "luckier" than others? Would you expect the same numbers or people to be "lucky" if we did the experiment again?

7. Would it be possible to be very "lucky" and roll
    10 1's in a row?

    100 1's in a row?

    1000 1's in a row?

    Would these happenings be likely?

8. Think of other experiments you could do besides these six that would give very similar results.

HOW TO MAKE A SPINNER THAT REALLY SPINS

1. Cut a circle from tag board. Poke a nice round hole exactly in the center.

2. Cut a square piece of tag board that's a little larger than the circle. Poke a hole through the center of this, too. Draw a line from the hole to one corner.

3. From the scraps left from cutting the circle, cut 3 little squares, about a cm. on a side each. They'll be used as washers. Poke a hole through each and crimp them a bit, too.

4. Take a paper clip and bend just the outside up.

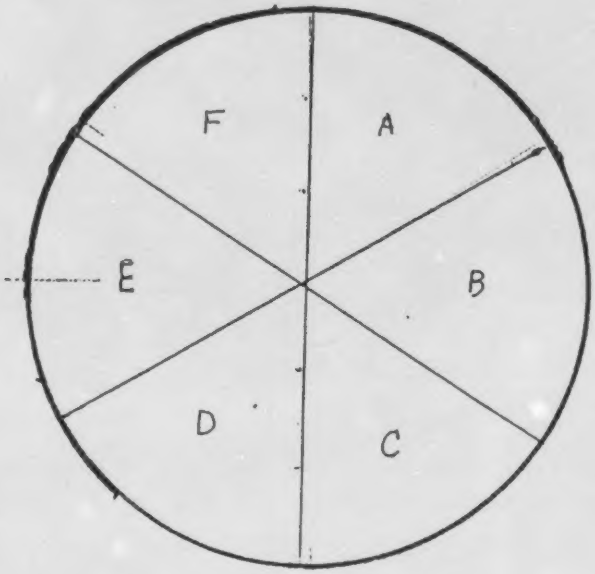
5. Cut a piece of masking tape that's about 4 cm or 5 cm long.

6. Assemble the spinner by first poking the paper clip through the square. Tape it on the bottom to hold it in place. Then put the three washers on.

7. Put the spinner face on next.

8. Add a piece of tape to cover the point of the paper clip.

9. Now it's ready to spin.



Beans in the Bag Worksheet

Bag Predictors: ______________________ **Bag Makers:** ______________________

______________________ ______________________

Draw Record

Color	Tally for 1st Ten Draws	Total No. Drawn after 10	Tally for 2nd Ten Draws	Total No. Drawn after 20	Tally for 3rd Ten Draws	Total No. Drawn after 30	Tally for 4th Ten Draws	Total No. Drawn after 40

Prediction

Color	After 10 Draws	After 20 Draws	After 30 Draws	After 40 Draws

Actual Count

Color	No. in Bag

Beans in the Bag
Discussion Worksheet

1. Was it easier to predict after 40 draws than after 10?
   Why or why not?

2. Did all three kinds of beans feel the same?
   Would a different feel affect results?

3. Suppose we had 100 beans in the bag instead of 25:
   How many would we need to sample to have a fairly accurate prediction?
   What if there were 1000 beans?

1 2 3 4 1 2 3 4

1 2 3 4 1 2 3 4

1 2 3 4 1 2 3 4

1 2 3 4 1 2 3 4

1 2 3 4 1 2 3 4

1 2 3 4 1 2 3 4

PRIME TIME
PROGRAM SCHEDULE WORKSHEET

Name________________________ Seed No.______

Enter the program category number under ATC and ETS. Use arrows to show the length of each program. To plan program schedule for PTN, enter category number and program name. (names should be limited to 2 lines of 10 spaces.)

NET WORK

	ATC	ETS	PTN
7:00			
7:30			
8:00			
8:30			
9:00			
9:30			
10:00			
10:30			

CATEGORIES
1. Game Show
2. Situation Comedy
3. Action/Adventure/Western Series
4. Dramatic Series
5. Movie
6. News
7. Documentary
8. Sports Event

PRIME TIME NETWORK RATING REPORT

NAME ____________________ SEED NO. __________

	SUMMARY: WEEKS 1-5						SUMMARY: WEEKS 6-10					
Network:												
	Cat.	Rating	Cat.	Rating	Cat.	Rating	Cat.	Rating	Cat.	Rating	Cat.	Rating
7:00												
7:30												
8:00												
8:30												
9:00												
9:30												
10:00												
10:30												
AVERAGE RATING	____		____		____		____		____		____	

OVERALL RATINGS

NETWORK	RATING

Currently Watching Research
Recording Sheet

Sample Size =

	ATC		ETS	
	Cat	#ON	Cat	#ON
7:00				
7:30				
8:00				
8:30				
9:00				
9:30				
10:00				
10:30				

Sample Size =

	ATC		ETS	
	Cat	#ON	Cat	#ON
7:00				
7:30				
8:00				
8:30				
9:00				
9:30				
10:00				
10:30				

Sample Size =

	ATC		ETS	
	Cat	#ON	Cat	#ON
7:00				
7:30				
8:00				
8:30				
9:00				
9:30				
10:00				
10:30				

People's Preferences Research
Recording Sheet

Sample Size =

Category	Favorite	Want More
1. Game		
2. Situation Comedy		
3. Action		
4. Drama		
5. Movie		
6. News		
7. Documentary		
8. Sports		

Sample Size =

Category	Favorite	Want More
1. Game		
2. Situation Comedy		
3. Action		
4. Drama		
5. Movie		
6. News		
7. Documentary		
8. Sports		

Sample Size =

Category	Favorite	Want More
1. Game		
2. Situation Comedy		
3. Action		
4. Drama		
5. Movie		
6. News		
7. Documentary		
8. Sports		

DATA ANALYSIS

Time 2 hours plus 3 or 4 10-15 minute periods from previous sessions.

Materials

For previous sessions
1 large piece of graph paper for each graph
Glue sticks or paste
Construction paper squares
Marking Pens

For this session
1 PET computer per 4 teachers
1 "Data Search" program per 4 teachers
1 blank copy of Questionnaire per 4 teachers
1 printout of Questionnaire data per 4 teachers
1 tape of Questionnaire data from "Data Maker" per 4 teachers
1 "Cosmic Explorer" program per 4 teachers
1 "Cosmic Explorer" data sheet per 4 teachers
1 "Science Officer's Manual" per 4 teachers
1 "Science Officer's Log Sheet" per 4 teachers
1 "Data Maker" program per 4 teachers
1 blank tape per 4 teachers

Suggested Time Frame

Time	Activity
5 min	Introduction
5 min	Student Graphs
25 min	Computer Analysis
40 min	Cosmic Explorer
40 Min	Data Maker
5 min	Summary

Overview For Master Teacher

The ability to look through data to make general conclusions is becoming an increasingly important in many aspects of work in our society. A primary reason for its increasing use as a tool for decision making and problem solving is the recent availability of inexpensive computers. Computers allow us to organize and to evaluate a large amount of data efficiently. Thus, it is becoming important for young pople to develop skills in handling data.

In general, there are two kinds of skills needed: generating hypotheses about the data and using computers as tools to check these hypotheses. This unit will provide students with the opportunity to develop both kinds of skills.

The first skill, generating hypotheses, is the ability to find patterns. To develop this skill, students and teachers learning to work with this unit need the freedom to guess and check in a supportive environment. Teachers, more often than their students, may feel uncomfortable in a situation where there is no one right answer and there are many good ways to approach the problem. You may need to give some teacher special support in this process.

The second skill, using the computer as a data analysis tool, will be foreign to most teachers as well as their students. In this unit, the computer can be used to make bar graphs, cross tabs and lists of data. In all cases, the data used can be limited to a part of the original data. Learning to use the tools will depend on experience using them in a trial and error situation. Again, many teachers will need support to risk some experimentation.

Before students can learn to use the computer to make bar graphs and cross tabs with data, they need the experience of making their own graphs and charts. Very few students will be able to understand what the computer is doing until they have done the work themselves. This meaning of graphs and charts will become clearer to students over time. Therefore, we suggest that teachers have their students make bar graphs and cross tabs over a period of weeks before beginning formal work in the unit. The exposure over time will allow the students to be more comfortable with these ways of representing data than they would if they see it all in one or two class periods.

It will be easier for teachers to use this technique of gradually exposing their students to these ideas if you model this behavior with them. Thus, we strongly suggest that you spend ten or fifteen minutes from the three or four inservice sessions before the session on Data Analysis having teachers make and discuss bar graphs and cross tabs.

After the gradual introduction of bar graphs and cross tabs, the formal work of the unit begins with students asking their own questions about the class and finding partial answers through the use of bar graphs and cross tabs. Then they use the computer as a tool to find out more about themselves. Next, they use the same tool to investigate fictitious beings from another planet, and, finally, they look at data from students in other classes.

Introduction

Time 5 minutes

Materials None

There are three important points to be made to the teachers:

- Much trial and error is involved in this unit.
- Bar Graphs and Cross Tabs should be introduced gradually.
- No previous knowledge of data analysis or statistics is needed to teach this unit.

Trial and Error

Explain to the teachers that two skills will be developed through this unit: generating hypotheses and checking those hypotheses with and without computers. Students need a supportive atmosphere to brainstorm hypotheses and to learn to use the capabilities of the computer. It is important that the students seek to make their own conclusions from data, and they need freedom to experiment while they are forming their conclusions.

Gradual Introduction

Explain the need for introducing Bar Graphs and Cross Tabs over a period of time. Point out that the way they have seen you introduce these graphs in previous sessions is a good way for them to introduce them.

No Special Knowledge

Reassure the teachers that they will need no previous knowledge of data analysis or statistics to use this unit. They will learn all they need to know about using the computer to examine data in this session. However, they will need to be able to encourage their students to make hypotheses and to test them.

Bar Graphs and Cross Tabulation

Time 3 or 4 10-15 minute periods done in previous sessions

Materials
1 large piece of graph paper for each group
Glue sticks or paste
Construction paper squares
Marking Pens

These activities are done prior to the Data Analysis Session. Before class, prepare several graphs as described in the activities "Bar Graphs" and "Cross Tabulations". The teachers should mark the graphs as they come into class. At the beginning of class, discuss the results and brainstorm ideas for summary sentences. Choose one sentence to write on each graph.

Use both bar graphs and cross tabulations in each session. After the first session, include examples with limiting variables (ie. where only part of the teachers mark the graph.) Save the resulting graphs for the "Student Graphs" activity.

Student Graphs

Time 5 minutes

Materials None

Describe the activity from the Teacher's Guide to the teachers. Emphasize that this will be the first opportunity for students to think of questions that might be answered by collecting and organizing data. Sketching the graph and making a prediction, the first two tasks for partners before making the graph, are important.

It is important to think through the categories that the responses to the question might include. Some questions offer too much information. For instance, asking about favorite ice cream may produce a graph that allows for chocolate, vanilla, strawberry, and other. Probably most responses will fall into the "other" category. In other cases, numerical questions may pose the problem of grouping the answers.

Many students will not frame their question correctly or set up their graph in a way that will get a clear result. Although teachers should certainly encourage students through questions to think through what they've done, some students may learn best from making mistakes. If might be a good idea to let them have a second chance to change their graph and/or to sharpen their question.

Computer Analysis

Time 25 minutes

Materials

1 blank copy of Questionnaire per 4 teachers
1 printout of Questionnaire data per 4 teachers
1 PET computer loaded with "Data Search" program per 4 teachers
1 tape of Questionnaire data from "Data Maker" per 4 teachers

Before class

Before class, you will need to do the following:

1. Prepare a questionnaire for the the teachers (a sample one is included in this guide).
2. Have the teachers and perhaps some of their friends fill in the questionnaire. (You will need about 30 filled-in questionnaires to reach any conclusions. You can mail out the questionnaires before class or use a a computer network, if available, to receive answers.)
3. Enter the data from the questionnaires in the "Data Maker" program and make tapes of the data (one tape per 4 teachers).
4. Make a printout of the data, using "Data Maker" (1 copy per 4 teachers).

During Class

Place one computer loaded with "Data Search" where everyone can see the screen. Show teachers how to load the data tape. Demonstrate the use of the computer to make a bar graph and a crosstabs. Using the printouts, teachers should begin to form hypotheses about themselves.

Then let the teachers work with a computer. They should load the data tape and try to find some conclusions about themselves.

About 5 minutes before the end of this activity, load "Cosmic Explorer" into the computers and ask them to discuss the conclusions they found.

Cosmic Explorer

Time 40 minutes

Materials

1 PET computer loaded with "Cosmic Explorer" per 4 teachers
1 "Cosmic Explorer" data sheet per 4 teachers
1 "Science Officer's Manual" per 4 teachers
1 "Science Officer's Log Sheet" worksheet per 4 teachers

Tell the teachers that now they can investigate beings from another planet, just as they investigated themselves. Let them work in groups around the computers to see what they can find out about Ugizians. They should start by looking at the data sheet. Once they have made a hypothesis, they should fill in a log sheet.

About 10 minutes before the end of this activity, let the teachers discuss their findings and the evidence they collected.

Explain that this activity is intended to be a whole class activity in that each group will add to the whole class' knowledge of Ugizians. That is, each succeeding day groups may start with the information the other groups collected.

Data Maker

Time 40 minutes

Materials

- 1 PET computer loaded with Data Maker per 4 teachers
- 1 blank tape per 4 teachers
- 1 "Data Search" tape per 4 teachers

Tell the teachers they will have to use the "Data Maker" program to store their students' questionnaire data. This activity is intended to show them how to use "Data Maker" and also the wider uses of the program.

Place one computer where everyone can see its screen. Briefly demonstrate how they will use the program to enter student data. Explain Numeric and Discrete data.

Tell them that they are to invent a population for others to study. The population could be people, countries, insects, clothes, or whatever they wish. They should pick 4 or 5 variables and invent 15 to 30 cases from the population. They should structure the cases so someone could make inferences about the population.

For example, if their population is insects, the variables could be number of legs, number of eyes, whether they have wings, and whether they have antennae. Then they could structure the cases so only 6-legged insects had antennae and all winged insects had 4 eyes.

Let each group of teachers invent a population and enter data using Data Maker. If time permits, groups can try to make inferences from other groups' data using the "Data Search" program. Point out to the teachers that there are many ways that they could use "Data Maker" and "Data Search" in their classrooms. Each population they invented could be part of a different classroom activity.

Summary

Time 5 minutes

Materials None

Discuss with the teachers the three points made in the introduction. In particular, ask them to describe how they learned through trial and error in this unit.

Computer Analysis Questionnaire

Please answer each question below:

1. What is your sex? (Circle one.)

Female
Male

2. What type of car do you usually drive: (Circle the best answer.)

Compact
Standard
Van or Station Wagon
Sports Car
No Car

3. How many children do you have? __________

4. Which of the following types of vacations would you prefer? (Circle the best answer.)

Camping
Staying in other cities
Being at a resort
Traveling around in a car or camper
Staying home

5. Which of the following colors do you prefer? (Circle one.)

Blue
Red
Yellow
Green
Purple

6. At what age did you (or will you) think of yourself as middle-aged?

____

7. How many thousands of dollars a year would you need to make to feel comfortable? __________

COSMIC DATA

CASE#	SEX	AGE	HT.	WT.	KIDS	EYES	HAIR	FEET	LOC.
1	DOSE	23	86	84	0	RED	YELLOW	13	1049
2	DEES	21	70	72	9	ORANGE	GREY	12	1057
3	DEM	1	37	2	0	BLUE	BALD	5	1065
4	DEM	24	56	25	0	BLUE	BROWN	9	1073
5	DEM	8	54	20	0	BLUE	BALD	9	1081
6	DOSE	17	83	61	6	ORANGE	GREY	14	1089
7	DEM	8	54	20	0	BLUE	BALD	9	1097
8	DOSE	15	85	49	0	ORANGE	YELLOW	14	1105
9	DEES	18	65	68	0	RED	BROWN	10	1113
10	DEES	14	64	62	0	ORANGE	BROWN	10	1121
11	DEES	23	74	79	0	ORANGE	BROWN	12	1129
12	DEES	23	73	80	9	RED	GREY	12	1137
13	DEM	5	44	11	0	BLUE	BALD	7	1145
14	DEES	13	55	62	3	RED	GREY	8	1153
15	DEM	4	43	9	0	BLUE	BALD	7	1161
16	DOSE	28	104	98	0	ORANGE	YELLOW	17	1169
17	DOSE	18	93	60	6	ORANGE	GREY	16	1177
18	DEES	1	40	5	0	BLUE	YELLOW	6	1185
19	DEES	16	63	70	6	RED	GREY	9	1193
20	DOSE	16	89	56	0	ORANGE	YELLOW	14	1201
21	DEES	15	65	69	6	RED	GREY	10	1209
22	DEES	24	82	85	9	RED	GREY	14	1217
23	DOSE	15	87	52	0	ORANGE	YELLOW	14	1225
24	DEM	3	39	7	0	BLUE	BALD	6	1233
25	DOSE	27	91	95	0	ORANGE	YELLOW	16	1241
26	DEES	4	49	21	0	BLUE	YELLOW	8	1249
27	DEM	25	56	23	0	YELLOW	BALD	10	1257
28	DEES	11	54	57	3	ORANGE	GREY	9	1265
29	DOSE	4	52	19	0	BLUE	BROWN	8	1273
30	DOSE	22	97	83	9	ORANGE	GREY	15	1281
31	DEM	12	54	25	0	BLUE	BROWN	9	1289
32	DEES	16	65	71	0	RED	BROWN	10	1297
33	DEES	21	72	74	0	RED	BROWN	11	1305
34	DOSE	13	81	41	0	RED	YELLOW	12	1313
35	DOSE	2	41	10	0	BLUE	BROWN	6	1321
36	DEES	19	69	66	0	RED	BROWN	12	1329
37	DEES	15	62	62	6	RED	GREY	10	1337
38	DOSE	2	46	9	0	BLUE	BROWN	7	1345
39	DOSE	16	91	55	6	ORANGE	GREY	14	1353
40	DEES	2	42	9	0	BLUE	YELLOW	7	1361
41	DOSE	27	103	107	9	ORANGE	GREY	17	1369
42	DEES	25	67	77	0	RED	BROWN	11	1377
43	DOSE	16	89	54	6	ORANGE	GREY	15	1385
44	DEM	17	53	25	0	BLUE	BROWN	7	1393
45	DOSE	18	96	64	6	ORANGE	GREY	16	1401
46	DOSE	16	97	55	0	ORANGE	YELLOW	16	1409
47	DEES	21	80	77	0	RED	BROWN	13	1417
48	DEM	4	44	10	0	BLUE	BALD	7	1425
49	DEES	23	70	78	0	RED	BROWN	11	1433
50	DOSE	27	97	98	0	RED	YELLOW	15	1441
51	DEM	25	57	22	0	YELLOW	BALD	9	1449
52	DEM	7	51	16	0	BLUE	BALD	8	1457
53	DEES	2	43	11	0	BLUE	YELLOW	6	1465
54	DEES	13	55	59	0	RED	BROWN	9	1473
55	DOSE	13	81	45	0	ORANGE	YELLOW	13	1481

```
 56   DEES 24    75   86   9     RED      GREY     13     1489
 57   DOSE  5    51   23   0     BLUE     BROWN     9     1497
 58   DEM   3    41    6   0     BLUE     BALD      6     1505
 59   DEES  2    42   10   0     BLUE     YELLOW    6     1513
 60   DOSE  2    43    9   0     BLUE     BROWN     6     1521
 61   DOSE 21    93   74   0     ORANGE   YELLOW   15     1529
 62   DEES  5    60   26   0     BLUE     YELLOW    9     1537
 63   DEES  5    48   24   0     BLUE     YELLOW    7     1545
 64   DEES 14    63   66   0     RED      BROWN    10     1553
 65   DOSE 18    87   65   0     ORANGE   YELLOW   13     1561
 66   DEES 23    76   84   9     RED      GREY     11     1569
 67   DEM  23    53   24   0     BLUE     BROWN     9     1577
 68   DOSE 19    98   69   6     RED      GREY     16     1585
 69   DOSE 26    92   88   9     ORANGE   GREY     16     1593
 70   DEES  1    36    5   0     BLUE     YELLOW    5     1601
 71   DEES 13    64   66   3     ORANGE   GREY     11     1609
 72   DEM  17    55   24   0     BLUE     BROWN     9     1617
 73   DEM  23    56   26   0     YELLOW   BALD      9     1625
 74   DEM  11    56   26   0     YELLOW   BALD      9     1633
 75   DEM   8    55   21   0     BLUE     BALD      9     1641
 76   DEES 15    65   67   0     RED      BROWN    11     1649
 77   DEES 21    73   75   9     RED      GREY     10     1657
 78   DOSE 28    93  101   0     ORANGE   YELLOW   14     1665
 79   DEES 11    59   54   0     RED      BROWN    10     1673
 80   DEM  17    51   25   0     BLUE     BROWN     8     1681
 81   DEM  15    56   25   0     YELLOW   BALD      8     1689
 82   DEM   8    56   19   0     BLUE     BALD     10     1697
 83   DOSE 11    83   34   3     ORANGE   GREY     12     1705
 84   DEES 18    65   68   0     RED      BROWN    11     1713
 85   DEES 17    66   73   0     RED      BROWN    10     1721
 86   DEM   5    47   13   0     BLUE     BALD      7     1729
 87   DEES 20    70   77   9     RED      GREY     12     1737
 88   DEES  3    44   17   0     BLUE     YELLOW    7     1745
 89   DEES 11    55   59   3     RED      GREY      8     1753
 90   DOSE 15    83   51   6     ORANGE   GREY     13     1761
 91   DOSE 12    78   36   0     ORANGE   YELLOW   12     1769
 92   DEM   1    35    2   0     BLUE     BALD      6     1777
 93   DOSE 12    80   37   0     ORANGE   YELLOW   13     1785
 94   DEES  2    40   10   0     BLUE     YELLOW    7     1793
 95   DEM   4    44    9   0     BLUE     BALD      7     1801
 96   DEES  2    40    8   0     BLUE     YELLOW    6     1809
 97   DOSE 17    84   52   0     ORANGE   YELLOW   12     1817
 98   DEES  2    43    9   0     BLUE     YELLOW    7     1825
 99   DEM  17    50   25   0     BLUE     BROWN     8     1833
100   DOSE 13    91   41   0     ORANGE   YELLOW   14     1841
101   DEES  2    44   10   0     BLUE     YELLOW    7     1849
102   DOSE  3    49   15   0     BLUE     BROWN     7     1857
103   DEES 24    83   79   0     RED      BROWN    12     1865
104   DOSE 13    80   44   0     ORANGE   YELLOW   13     1873
105   DOSE 18    87   68   6     ORANGE   GREY     13     1881
106   DEES 21    80   77   0     RED      BROWN    13     1889
107   DEES 24    71   79   9     RED      GREY     11     1897
108   DEES 11    60   53   0     RED      BROWN     9     1905
109   DEES 21    71   78   0     RED      BROWN    11     1913
110   DOSE 22    92   80   9     ORANGE   GREY     16     1921
111   DOSE 17    80   57   6     ORANGE   GREY     12     1929
112   DEES 14    64   60   3     ORANGE   GREY     10     1937
113   DEES 16    64   66   6     RED      GREY     10     1945
114   DOSE  4    55   19   0     BLUE     BROWN     9     1953
115   DEES 24    80   91   9     RED      GREY     12     1961
```

```
 16  DOSE 27   101  106   9    ORANGE  GREY    16     1969
117  DEES 20    65   70   9    ORANGE  GREY    11     1977
 18  DOSE 30    97  106   0    ORANGE  YELLOW  16     1985
 19  DEES 23    73   77   0    RED     BROWN   12     1993
 20  DEES 14    63   61   3    RED     GREY    10     2001
 21  DEM  24    51   27   0    BLUE    BROWN    8     2009
 22  DOSE 19    82   69   6    RED     GREY    13     2017
 23  DEES 12    59   59   3    RED     GREY     9     2025
 24  DEES 24    72   78   9    ORANGE  GREY    11     2033
 25  DEM  16    56   24   0    YELLOW  BALD     9     2041
 26  DEES 21    75   85   9    RED     GREY    12     2049
 27  DOSE  4    53   19   0    BLUE    BROWN    8     2057
 28  DEES 11    61   55   0    ORANGE  BROWN    9     2065
 29  DEES 12    65   55   3    RED     GREY    11     2073
 30  DEES 19    72   71   6    RED     GREY    12     2081
 31  DEES 24    75   74   9    ORANGE  GREY    12     2089
 32  DEES  2    43    9   0    BLUE    YELLOW   7     2097
 33  DEES 17    63   64   6    RED     GREY     8     2105
 34  DOSE  2    38    9   0    BLUE    BROWN    6     2113
 35  DEM  19    58   23   0    BLUE    BROWN    9     2121
 36  DOSE 11    75   35   0    ORANGE  YELLOW  12     2129
 37  DOSE 11    79   32   3    ORANGE  GREY    12     2137
 38  DOSE 26    90   93   9    ORANGE  GREY    15     2145
 39  DEES 21    75   76   9    RED     GREY    11     2153
 40  DEES 11    59   60   3    RED     GREY    10     2161
 41  DEM  15    56   26   0    BLUE    BROWN    9     2169
 42  DEES 16    66   63   0    RED     BROWN   10     2177
 43  DEM  14    53   27   0    BLUE    BROWN    9     2185
 44  DOSE 19    89   61   6    RED     GREY    15     2193
 45  DEM   5    45   11   0    BLUE    BALD     7     2201
 46  DOSE 19    96   65   0    ORANGE  YELLOW  15     2209
 47  DOSE 23    88   77   9    ORANGE  GREY    14     2217
 48  DEES  2    41   10   0    BLUE    YELLOW   6     2225
 49  DOSE  1    40    5   0    BLUE    BROWN    6     2233
 50  DEES 17    73   69   0    RED     BROWN   11     2241
  1  DEES 18    72   75   6    ORANGE  GREY    11     2249
  2  DEES 15    65   66   6    RED     GREY    11     2257
  3  DEES 24    78   84   0    RED     BROWN   12     2265
  4  DOSE 13    80   40   0    ORANGE  YELLOW  13     2273
 55  DEM  17    54   26   0    YELLOW  BALD     9     2281
 56  DEES 18    64   77   6    ORANGE  GREY    10     2289
 57  DOSE 18    89   59   0    ORANGE  YELLOW  14     2297
     DEES 22    81   82   0    RED     BROWN   13     2305
     DEM   5    42   12   0    BLUE    BALD     6     2313
  0  DEM   3    40    6   0    BLUE    BALD     7     2321
  1  DEES  1    39    5   0    BLUE    YELLOW   7     2329
  2  DEES 24    76   73   9    RED     GREY    12     2337
     DEES 23    76   78   9    RED     GREY    13     2345
  4  DEM  20    47   24   0    BLUE    BROWN    7     2353
     DEES  3    44   15   0    BLUE    YELLOW   6     2361
     DEM   3    41    7   0    BLUE    BALD     7     2369
     DEM  16    51   23   0    BLUE    BROWN    7     2377
     DEES 17    72   69   6    RED     GREY    11     2385
     DEES 24    80   93   0    RED     BROWN   13     2393
     DOSE 18    96   63   6    ORANGE  GREY    14     2401
     DEES 24    80   89   9    ORANGE  GREY    13     2409
     DEES 17    64   72   6    RED     GREY    10     2417
     DOSE  5    51   25   0    BLUE    BROWN    8     2425
     DEES 13    62   65   0    RED     BROWN   10     2433
     DEES 12    58   60   0    RED     BROWN    8     2441
```

```
176   DEES 17    64   71   0     RED      BROWN    10     2449
177   DEES  2    43    9   0     BLUE     YELLOW    6     2457
178   DOSE 28    93  104   9     ORANGE   GREY     14     2465
179   DOSE  4    54   19   0     BLUE     BROWN     9     2473
180   DEES  5    54   24   0     BLUE     YELLOW    9     2481
181   DOSE 17    86   59   0     ORANGE   YELLOW   14     2489
182   DEES  4    53   20   0     BLUE     YELLOW    8     2497
183   DEM  16    54   23   0     YELLOW   BALD      8     2505
184   DOSE  5    62   25   0     BLUE     BROWN     9     2513
185   DEES 24    79   81   0     RED      BROWN    13     2521
186   DEES 19    64   74   6     RED      GREY     10     2529
187   DEES  3    45   16   0     BLUE     YELLOW    7     2537
188   DEES  1    39    4   0     BLUE     YELLOW    6     2545
189   DEES 21    82   81   9     RED      GREY     13     2553
190   DOSE 16    83   57   0     RED      YELLOW   13     2561
191   DOSE 12    85   35   3     RED      GREY     14     2569
192   DOSE 27    92   84   0     ORANGE   YELLOW   15     2577
193   DOSE 11    75   32   0     ORANGE   YELLOW   13     2585
194   DOSE 11    81   32   3     ORANGE   GREY     14     2593
195   DOSE 25    87   83   0     ORANGE   YELLOW   13     2601
196   DEES 17    71   69   0     ORANGE   BROWN    12     2609
197   DEES 21    72   79   9     ORANGE   GREY     11     2617
198   DOSE 27    98   94   9     ORANGE   GREY     14     2625
199   DOSE  1    38    4   0     BLUE     BROWN     6     2633
200   DEM  20    57   27   0     BLUE     BROWN     9     2641
201   DOSE 25   100   87   9     ORANGE   GREY     16     2649
202   DEES 14    57   66   3     ORANGE   GREY      9     2657
203   DEES 14    64   57   3     ORANGE   GREY     10     2665
204   DOSE 14    85   43   3     ORANGE   GREY     14     2673
205   DEES  3    44   16   0     BLUE     YELLOW    7     2681
206   DEES 14    61   62   0     RED      BROWN    10     2689
207   DEES 21    71   72   0     RED      BROWN    11     2697
208   DOSE 28    97  103   0     RED      YELLOW   14     2705
209   DOSE  3    49   13   0     BLUE     BROWN     7     2713
210   DEES 15    68   62   0     RED      BROWN    10     2721
211   DEM  16    52   25   0     YELLOW   BALD      8     2729
212   DEM  22    50   26   0     YELLOW   BALD      8     2737
213   DEES 20    76   78   9     ORANGE   GREY     13     2745
214   DEES 25    88   88   0     RED      BROWN    14     2753
215   DEES 17    65   69   6     ORANGE   GREY     10     2761
216   DEM   4    42   10   0     BLUE     BALD      7     2769
217   DEES 18    74   70   0     RED      BROWN    12     2777
218   DEES  3    44   13   0     BLUE     YELLOW    6     2785
219   DEES  4    44   19   0     BLUE     YELLOW    7     2793
220   DEES 15    69   63   0     RED      BROWN    11     2801
221   DEM  16    56   25   0     YELLOW   BALD      9     2809
222   DOSE 12    85   37   3     ORANGE   GREY     13     2817
223   DOSE 17    88   58   6     ORANGE   GREY     14     2825
224   DEES 12    60   60   0     RED      BROWN    10     2833
225   DEES  5    57   26   0     BLUE     YELLOW   10     2841
226   DEES  1    39    5   0     BLUE     YELLOW    6     2849
227   DOSE 27    95   95   9     ORANGE   GREY     16     2857
228   DOSE 26    96   90   0     ORANGE   YELLOW   16     2865
229   DEES  4    46   19   0     BLUE     YELLOW    7     2873
230   DEES  2    43   10   0     BLUE     YELLOW    7     2881
231   DEES 18    74   68   0     RED      BROWN    12     2889
232   DEES 14    62   59   0     RED      BROWN    11     2897
233   DOSE 17   100   58   6     RED      GREY     16     2905
234   DOSE 13    76   40   3     ORANGE   GREY     12     2913
235   DEES 22    75   83   9     RED      GREY     11     2921
```

236	DEES	5	52	24	0	BLUE	YELLOW	8	2929
237	DEES	16	65	68	0	RED	BROWN	10	2937
238	DEES	14	59	58	3	RED	GREY	10	2945
239	DEES	20	73	73	0	RED	BROWN	12	2953
240	DEES	3	46	14	0	BLUE	YELLOW	7	2961
241	DEES	1	37	5	0	BLUE	YELLOW	5	2969
242	DEES	23	79	77	9	RED	GREY	13	2977
243	DOSE	22	85	73	9	RED	GREY	12	2985
244	DOSE	23	92	79	9	RED	GREY	15	2993
245	DEES	11	53	55	0	RED	BROWN	8	3001
246	DOSE	24	87	85	9	ORANGE	GREY	15	3009
247	DOSE	5	55	24	0	BLUE	BROWN	9	3017
248	DEES	3	45	14	0	BLUE	YELLOW	7	3025
249	DOSE	24	89	91	9	ORANGE	GREY	13	3033
250	DEES	16	65	70	6	ORANGE	GREY	11	3041
251	DOSE	2	44	10	0	BLUE	BROWN	7	3049
252	DEES	21	70	72	0	ORANGE	BROWN	12	3057
253	DOSE	12	86	38	0	ORANGE	YELLOW	13	3065
254	DEM	9	56	22	0	BLUE	BALD	8	3073
255	DEES	22	76	81	9	ORANGE	GREY	12	3081
256	DOSE	18	86	63	0	ORANGE	YELLOW	14	3089
257	DOSE	13	74	41	3	ORANGE	GREY	12	3097
258	DEES	2	41	10	0	BLUE	YELLOW	6	3105
259	DEM	9	55	20	0	BLUE	BALD	9	3113
260	DEM	20	53	25	0	YELLOW	BALD	9	3121
261	DOSE	3	48	13	0	BLUE	BROWN	7	3129
262	DOSE	3	45	15	0	BLUE	BROWN	7	3137
263	DEES	11	59	55	3	RED	GREY	9	3145
264	DOSE	5	61	24	0	BLUE	BROWN	10	3153
265	DEM	22	50	22	0	YELLOW	BALD	8	3161
266	DEM	24	56	23	0	BLUE	BROWN	8	3169
267	DOSE	3	51	14	0	BLUE	BROWN	9	3177
268	DEES	17	68	69	6	RED	GREY	10	3185
269	DEES	3	48	16	0	BLUE	YELLOW	7	3193
270	DEES	18	68	73	0	RED	BROWN	10	3201
271	DOSE	28	93	109	9	ORANGE	GREY	14	3209
272	DOSE	5	56	25	0	BLUE	BROWN	9	3217
273	DEES	18	72	69	6	RED	GREY	11	3225
274	DEM	7	51	17	0	BLUE	BALD	8	3233
275	DEM	15	55	25	0	YELLOW	BALD	9	3241
276	DOSE	24	94	90	0	ORANGE	YELLOW	16	3249
277	DEES	3	46	15	0	BLUE	YELLOW	7	3257
278	DEES	18	71	76	6	RED	GREY	11	3265
279	DEM	21	60	24	0	BLUE	BROWN	8	3273
280	DOSE	21	86	69	0	RED	YELLOW	14	3281
281	DOSE	11	78	35	3	ORANGE	GREY	11	3289
282	DEM	11	56	26	0	YELLOW	BALD	9	3297
283	DOSE	11	84	31	0	ORANGE	YELLOW	14	3305
284	DEES	22	81	79	0	RED	BROWN	13	3313
285	DEES	25	79	86	9	RED	GREY	14	3321
286	DEES	12	60	60	0	RED	BROWN	9	3329
287	DEES	17	69	70	0	RED	BROWN	10	3337
288	DOSE	22	94	78	9	RED	GREY	16	3345
289	DEES	16	67	69	6	ORANGE	GREY	11	3353
290	DEES	11	53	57	3	RED	GREY	8	3361
291	DOSE	21	95	79	0	ORANGE	YELLOW	15	3369
292	DEES	3	46	14	0	BLUE	YELLOW	7	3377
293	DEES	11	55	58	3	RED	GREY	9	3385
294	DEES	11	58	56	0	RED	BROWN	9	3393
295	DEM	25	55	25	0	BLUE	BROWN	9	3401

```
296   DOSE 22    97   75   0     ORANGE  YELLOW  16    3409
297   DOSE 26   107  103   9     ORANGE  GREY    17    3417
298   DEM  22    56   23   0     BLUE    BROWN    9    3425
299   DOSE 14    92   46   3     ORANGE  GREY    16    3433
300   DEES  3    42   15   0     BLUE    YELLOW   6    3441
```

COSMIC EXPLORER

SCIENCE OFFICER'S MANUAL

EVIDENCE FOR CONCLUSIONS

Some conclusions will require evidence to prove them. The evidence page is on the back of each SCIENCE OFFICER'S LOG SHEET. There are three types of recording you are to do on this side.

1. **CONCLUSION** - This is a copy of the conclusion you made on the SCIENCE OFFICER'S LOG SHEET.

2. **STATEMENT** - These are ideas you want to point out to help you prove your conclusion. There is space for two statements; others may be attached if needed.

3. **GRAPH** - This graph is a picture to display the data for your statement and/or conclusion. This is copied from the screen with the important variables and numbers filled in.

< SAMPLE >

GROUP NAMES ____________ ____________ ____________

SCIENCE OFFICER'S LOG SHEET

I. TYPE OF RESEARCH (CHECK ONE)

☐ BEGINNING STUDY OF DATA
☐ EXPLORATION OF A VARIABLE: __________
☐ IN-DEPTH STUDY OF ________________
☐ REVIEW OR CHECK OF EARLIER CONCLUSIONS
☐ OTHER ____________________________

II. STATEMENT OF PURPOSE

III. ITEMS THAT WERE INTERESTING

IV. CONCLUSIONS (EVIDENCE MAY BE NECESSARY)

V. IDEAS TO CHECK ON NEXT TIME

II. STATEMENT OF PURPOSE

This is the place to tell why you are doing what you are doing. Be clear; use complete sentences. A question about what you want to check is often useful.

Example 1. We want to investigate what data is available to work on. Can we find an interesting variable or combination of variables for our study?

Example 2. We want to study hair color to see if it is related to eye color. Also, does the most common hair color change for different ages?

Example 3. We think that the taller individuals have fewer children than shorter ones. Do shorter parents have more children?

III. ITEMS THAT WERE INTERESTING

This is a record of things you noticed as you were looking at the data. You might record things that someone else might want to study or things that would help a different group if they knew about them.

Example 1. We noticed that there were no children with brown hair.

Example 2. It seems that one-fourth of the people have blue eyes.

Example 3. The youngest parent we noticed was only eleven years old.

IV. CONCLUSIONS

This is where you record what you found out. Ideally, it will be an answer to the question in your STATEMENT OF PURPOSE. You may need to complete an evidence page to support your conclusions.

Example 1. We noticed that all the people with red hair have blue eyes.

Example 2. We discovered that the older a person is, the taller he becomes. We also noticed that there are more older people with green eyes than with brown eyes.

Example 3. Females with blue eyes are shorter than females with brown eyes.

V. IDEAS TO CHECK ON NEXT TIME

This is your chance to follow up something interesting. If you notice something about your variable but don't have time to check it now, you can note it here.

Example 1. We think that about half of the redheaded females have no children, but all the redheaded males seem to have children.

Example 2. It seems as if the taller individuals have no hair. Maybe it depends on their age or their sex.

Example 3. We can't figure out why there are no people who weigh more than 25 kilograms.

SUMMARY

There are many ideas to try in searching for information from the data. The use of LIMITING VARIABLES is particularly important in making comparisons between groups. LIMITING VARIABLES can also be used to look at smaller subgroups of a particular variable. You are able, for example, to compare males taller than 100 cm. with females shorter than 100 cm. Red-headed tall people could be compared with brown-haired tall people. You have to decide what you think is important or interesting.

Finally, don't overlook the DATA LIST option. You can often get additional information and new ideas by looking carefully at the DATA LIST for clues.

There are many unusual ideas and people to learn about as science officer on the **COSMIC EXPLORER. GOOD HUNTING!**

INTRODUCTION

As Science officer on board the **COSMIC EXPLORER**, you will be responsible for making conclusions about the planets and any life forms that may exist.

Data will be made available to you through your computer. The data will consist of information about the individuals from the planet being explored.

Your task will be to examine the data, decide what variables you want to study, and report your conclusions. You will keep a careful record of all your explorations and conclusions in the SCIENCE OFFICER'S LOG.

IMPORTANT

In order to proceed, you must be familiar with the DATA SEARCH program.

HOW TO BEGIN

Each SCIENCE OFFICER'S LOG SHEET is your record of an exploration you have done. There are five items on the front side of each log sheet. The back of the page is for evidence. What follows is a brief description of each item with examples to help you.

I. TYPE OF RESEARCH

The box you check tells what stage you're working on: beginning, middle, or end.

BEGINNING STUDY OF DATA
This is checked when you first start. You will probably reach no conclusions at this time, but at the end of this study you should have a good idea what information is available.

EXPLORATION OF A VARIABLE
After deciding what variable you want to explore, you check this box and try to find out as much as you can about that variable.

IN-DEPTH STUDY OF_______________
This is checked when you want to make a further study of a variable, or combination of variables, that interest you.

REVIEW OR CHECK OF EARLIER CONCLUSION
to provide evidence or to check out a new idea about your conclusion.

EVIDENCE FOR CONCLUSIONS

CONCLUSIONS: ______________________________

____

EXHIBIT A

STATEMENT ____________________

____

____

____

EXHIBIT B

STATEMENT ____________________

____

____

____

GROUP NAMES

____
____
____

SCIENCE OFFICER'S LOG SHEET

I. TYPE OF RESEARCH (CHECK ONE)

☐ BEGINNING STUDY OF DATA
☐ EXPLORATION OF A VARIABLE: _________
☐ IN-DEPTH STUDY OF _________________
☐ REVIEW OR CHECK OF EARLIER CONCLUSIONS
☐ OTHER __________________________

II. STATEMENT OF PURPOSE

III. ITEMS THAT WERE INTERESTING

IV. CONCLUSIONS (EVIDENCE MAY BE NECESSARY)

V. IDEAS TO CHECK ON NEXT TIME

95

EVIDENCE FOR CONCLUSIONS

CONCLUSIONS:

EXHIBIT A

STATEMENT

EXHIBIT B

STATEMENT

TURTLE GEOMETRY

Time 2 hours

Materials
- 2 pieces of grid paper for each teacher
- 1 Turtletractor for each teacher
- 1 pushpin for each teacher
- 1 8 1/2" X 11" piece of cardboard for each teacher
- 1 overhead projector with a transparency sheet
- 1 PET computer for each 6 teachers
- 1 "Turtleworks" Computer Program
- 1 Turtle Commands Summary Sheet for each teacher
- 1 "Regular Polygon Family" Worksheet for each teacher
- 1 "Turtleworks Pictures" Worksheet for each teacher
- 1 "Hook" Worksheet for each teacher

Suggested Time Frame

Time	Activity
5 min	Introduction
15 min	The Need for a Geometry Language
15 min	Introduction of Turtletalk
20 min	The Regular Polygon Family
30 min	Turtleworks Pictures
30 min	The Hook Family
5 min	Summary

Overview for Master Teacher

This unit builds on work done by Seymour Papert and his group at NIT. Papert's idea was to create a "Mathland" for students in which they could learn mathematics. Since the best way to teach students French is to send them to France, Papert reasoned that the best way to teach students math was to put them in a situation where they needed to speak mathematics to find their way around. In this unit, students use a geometry language to create delightful pictures on the computer screen.

The motivation to create a new language is provided by an activity where students describe a drawing they've made to another student. Then a language is introduced by which students can direct the movements of imaginary turtles on the computer screen. The turtles draw lines as they move. To understand how the turtles follow directions, students need the concrete experience of making drawings as turtles do. Turtle tractors provide this experience.

The students use the turtletractors to learn some properties of angles of regular polygons while they are building an understanding of how turtles move. Finally, while half the class creates turtle drawings on the computer, the other half works off the computers, seeing how very simple figures, hooks, can be combined to make complex and beautiful designs.

Introduction

Time 5 minutes

Materials None

Tell the teachers about Papert's use of Mathlands. In this unit they will see computers used to teach geometry in a way that it couldn't be taught without computers. Here the students must use the language of angles and lines in a precise way in order for turtles to draw what they want drawn.

The Need for a Geometry Language

Time 15 minutes

Materials

2 pieces of grid paper for each teacher

Ask the teachers to work in pairs so that they cannot see their partners' papers. Give everyone two sheets of grid paper and tell them to connect points on the intersections to make a simple picture. Stop them after about a minute so that their pictures aren't too complicated.

Tell them to take turns describing their picture to their partner as their partner attempts to copy the picture on the unused sheet of grid paper. During the description, neither person should see the other's work. The person trying to copy the picture can ask questions.

When a pair finishes, they can repeat the exercise if they wish, or they can do the optional activity. In that activity, they spend a few minutes devising a sign language code, then they use that code to describe a picture.

Stop everyone several minutes before the 15-minute period is up. Write a list of the words they found useful on the chalkboard.

Introduction of Turtletalk

Time 15 minutes

Materials

1 Turtletractor for each teacher
1 pushpin for each teacher
1 8 1/2" X 11" piece of cardboard for each teacher
1 overhead projector with a transparency sheet
1 PET computer loaded with the "Turtleworks" program

Pass out a turtletractor, pushpin, and piece of cardboard for each teacher as they are finishing the last activity.

Tell the teachers that they could use many different words when directing a human being. Now they will learn how to direct turtles to draw pictures. The turtles only understand a few words. They will use the words **GO** and **TURN** to tell a turtle how to move. As the turtle moves, it drags a pen that leaves a mark.

Ask the teachers what they think the turtle will do if they say

```
GO 10
TURN 90
GO 10
TURN 90
GO 10
TURN 90
GO 10
TURN 90
```

(Write these instructions on the blackboard.)

In the discussion, it should become clear that they don't know

a) where the turtle starts;

b) which way it faces;

c) what unit the 10 refers to; or

d) which way the turtle turns.

These are conventions. We have decided to have the turtle start in the center, face toward the right, and turn counterclockwise. We could have made other decisions. It is important for students to learn that many things in mathematics are based on conventions (ie., arbitrary decisions made for the sake of agreement).

Have each teacher place a piece of paper on the chalkboard, and pin their turtle tractor to the center of the paper. The turtle should face right. Pin your turtle tractor to the center of the transparency, facing right.

GO 10 means that the trutle moves to the tenth mark on the turtle tractor. (Note: The second mark is the turtle's mouth. The fifth mark is the first long line, and the tenth is the longer line after the "180". Everyone should hold their turtle tractor down with one hand, remove the pin with the other, and push the pin into the tenth mark on the tractor. When they remove the tractor, they will see two pin pricks on the paper. They should connect those two marks with a pencil. That line is the turtle's trail. Now pin the turtle to the second mark. It should still face right.

Show the teachers on the overhead that the turtle's trail lines on the tractor line marked "0". As you move your tractor counter-clockwise, lines with other numbers cross the turtle's trail. They should move their tractor until the line "90" lines along the trail. This is what TURN 90 means. Have the teachers carry out the other instructions on the chalkboard as you go through them on the overhead. Everyone should get a square.

Tell them there is a shorter way to write those instructions. Since the instructions are just GO 10 TURN 90 written 4 times, they could say

```
REPEAT 4 (GO 10 TURN 90)
```

or they can abbreviate REPEAT by RPT.

Type this into the computer and let them watch the square being made on the screen. You can tell them about 5 other commands:

CLEAR - erases the instructions and starts the program over.
LIST - shows the instructions.
DRAW - clears the screen and has the turtle follow all instructions.
PENUP - allows the turtle to move without leaving a trail.

There is a worksheet for students to practice using turtle tractors. However, the teachers can practice during the next activity.

The Regular Polygon Family

Time 20 minutes

Materials
1 Turtletractor for each teacher
1 pushpin for each teacher
1 8 1/2" x 11" cardboard sheet for each teacher

1 "Regular Polygon Family" worksheet for each teacher
1 PET computer loaded with "Turtleworks" program

Have the teachers work in groups of twos or threes. Give each teacher a worksheet. Tell them they are going to find patterns for making regular polygons.

Ask everyone to try to follow the turtle talk command ho!qsnamdl!0!nn the worksheet. Some teachers will probably need help. As other te`bidsr!ghohri- they can provide help. Whenever one has made the hexagon, have them turn to the chart on page two.

Point out that they have already made a square. On the line of the chart for the square, they can write:

RPT 4 (GO 10 TURN 90)

Ask them how much turning the turtle did in all (answer: 360 degrees). They can fill in "360 degrees" under "Total Turning" on the line for the square.

Now let them finish filling in the chart. They can check answers on the computer if they wish. Teachers who finish early can try the "Homework on Regular Polygon" page or they can help others. About 5 minutes before the end of the time for this activity, go through the "Class Discussion" on pages 16 and 17 of the "Turtle Geometry Teacher's Guide."

Many teachers will be puzzled since they think of angles for equilateral triangles as being 60 degrees. Point out that 60 degrees is the interior angle of the triangle, not the angle the turtle turns through when it makes the triangle. (Note that the turtle's angle is always 180 minus the interior angle.)

The last two activities can be done in any order. Thus, half the class can work on one activity while the other half works on the other. Then the two halves can change. Both groups will need to learn the new command (MULTIPLYBY or MULT) described under the next activity.

Turtleworks Pictures

Time 30 minutes

Materials
1 PET computer loaded with "Turtleworks" for each group
1 "Turtleworks Pictures Worksheet" for each teacher

Before splitting the class into two groups, go over the introduction of **MULT** and **COLLAPSE** on page 19 of the "Turtle Geometry Teacher's Guide." It is important for you to have the teachers act out the command, so that they will be more likely to use this technique with their own students.

Have the teachers work in twos or threes at the computer on the "Turtleworks Pictures Worksheet."

The Hook Family

Time 30 minutes

Materials

1 Turtletractor for each teacher
1 pushpin for each teacher
1 8 1/2" x 11" cardboard sheet for each teacher
1 "The Hook Worksheet" for each teacher

The teachers should have seen the Multiplyby demonstration at the beginning of the last activity. Since The Hook Family can be challenging, it is best for teachers to work in threes for this activity. Give each teacher a worksheet. They do not need to check every answer with a turtle tractor. They can check most answers by drawing freehand.

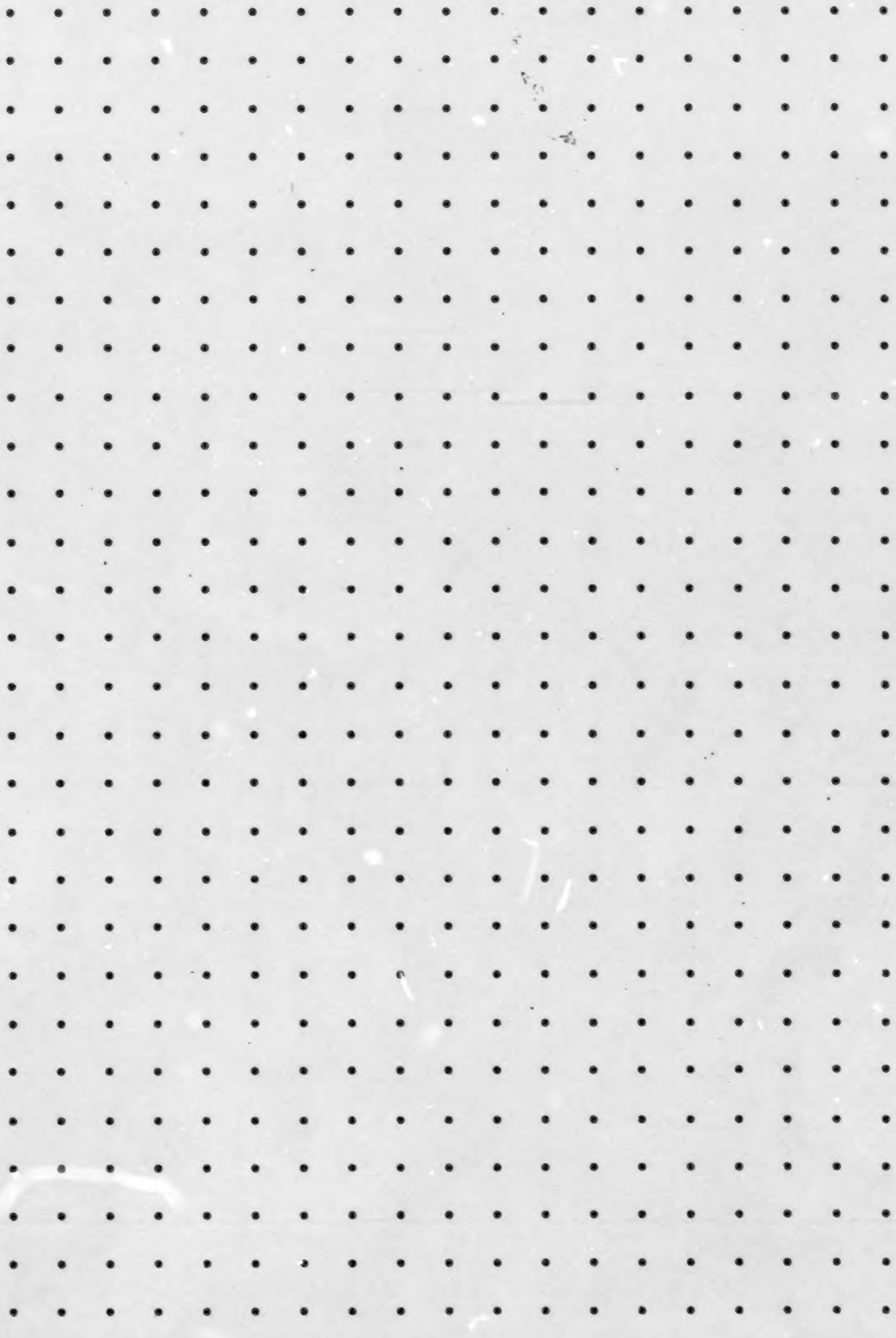
Summary

Time 5 minutes

Materials None

Ask the teachers to discuss their experiences with Turtle Geometry. Stress the importance of the concrete work off the computer.

103



TURTLETALK COMMANDS SUMMARY

Math Network Curriculum Project
San Francisco State University
March, 1982

HELP (abbreviated as H) - lists these commands.

GO - for example,

```
GO 10
```

sends all turtles forward 10 screen dots.

TURN - for example,

```
TURN 45
```

turns all turtles by 45 degrees in the counter-clockwise direction.

CLEAR - erases screen; gets rid of all turtles but one, and puts that turtle in the middle of the screen. Instructions in the main program are forgotten, but procedures are remembered.

REPEAT (abbreviated as RPT) - for example,

```
RPT 4 (GO 10 TURN 90)
```

causes the instructions GO 10 TURN 90 to be repeated 4 times, thus drawing a square.

MULTIPLYBY (abbreviated as MULT) - for example,

```
MULT 6 GO 15
```

causes there to be six active turtles in place of every one that was there before. All of these new turtles now move forward 15 screen dots.

COLLAPSE - the opposite of MULTIPLYBY. The turtles will be returned to the state they were in just before the last MULTIPLYBY. The screen will not be affected.

PENUP - After issuing this command, when the turtles move, they will not draw lines.

PENDN - The turtles will now draw as they move.

QUIT - Ends the program. Be sure to end this way if you wish to make a copy of TURTLEWORKS on tape.

LIST - Show commands executed since last CLEAR.

DRAW (abbreviated as D) - Clear the screen and start executing commands.

TO - Begin a procedure definition. For example,

```
TO SQUARE
RPT 4 (GO 10 TURN 90)
TURN 45
END
```

will mean that the turtles understand SQUARE from then on (unless you stop the program and start over). In fact you can say SQUARE 8 which will repeat the procedure 8 times, making a very pretty design.

END - Signals the end of a procedure definition.

EDIT - allows editing of individual commands. By itself it brings up the first command. Use DEL to change and retype. When finished hit <return>. If you don't want to change the command, you can hit <return> (and the command will be executed) or hold down the <shift> key and type @ (in which case the line will be skipped over).

```
EDIT 4
```

allows editing of the 4th command.

```
EDIT SQUARE
```

brings up the first step in the SQUARE procedure for editing.

```
EDIT SQUARE 2
```

brings up the 2nd step in the SQUARE procedure for editing.

TAPESAVE - for example,

```
TAPESAVE FLOWER
```

will write your TURTLETALK commands on a tape with the name **FLOWER** for later retrieval.

TAPELOAD - for example,

```
TAPELOAD FLOWER
```

will load the TURTLETALK commands named FLOWER from a tape.

NETNAMES (requires modem connection to MNCP Network)

This command by itself will list the names of all the turtle creations to be found on the MNCP network. If you follow the command by a letter or letters, it will list the names of all turtle creations that **begin** with that letter or letters. For example,

```
NETNAMES FL
```

might produce the list

```
FLAGS
FLOWER
FLOWER2
```

NETSAVE (requires modem connection to MNCP Network) - for example,

```
NETSAVE BIGFLOWER
```

allows you to save your TURTLETALK commands on the MNCP Network under the name **BIGFLOWER** for later retrieval by you or someone else.

NETLOAD (requires modem connection to MNCP Network) - for example,

```
NETLOAD BIGFLOWER
```

allows you to load BIGFLOWER from the MNCP Network.

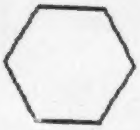
NETDELETE (requires modem connection to MNCP Network) - for example,

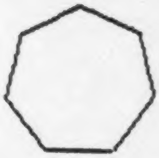
```
NETDELETE BIGFLOWER
```

allows you to delete BIGFLOWER from the MNCP Network.

Other notes:

- Holding down the **shift** key and typing @ will allow you escape from most operations.
- See the **Turtleworks User Manual** for a more detailed explanation of these commands.





Name_______________________

Group______________________

Date_______________________

The Regular Polygon Family Worksheet

Materials: You will need paper, pencil, a 'turtle-tractor', and an 8 1/2 x 11 sheet of cardboard

You should already know the following Turtletalk commands:

GO
TURN
REPEAT (abbreviated as **RPT**)

1. Use your turtle-tractor to make the drawing produced by

RPT 6 (GO 5 TURN 60)

Your turtle had to turn 60 degrees 6 times. How many degrees did it have to turn altogether?_________

We call this number the **total turning** of the turtle.

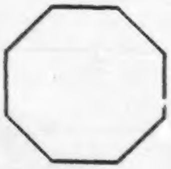
Did you end up drawing a six-sided figure with all sides equal? This figure is called a **hexagon**.

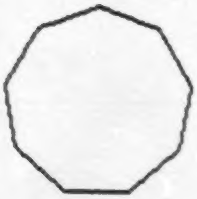
The Regular Polygon Family Worksheet

2. A hexagon is a kind of **polygon**. (The word 'polygon' literally means **many-sides**.) Polygons which have all sides equal and all angles equal like the hexagon you drew are called **regular polygons**.

   Figure out how to draw the regular polygons listed in the chart below. For each one you draw, compute the total turning just like you did for the regular hexagon. Show in the chart the Turtletalk program you used to produce the polygon.

Number of sides	name of polygon	Turtletalk commands	Total Turning
3	triangle		
4	square		
6	hexagon	RPT 6 (GO 5 TURN 60)	360 degrees
8	octagon		
9	nonagon		





Name________________________

Group_______________________

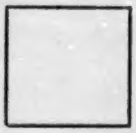
Date________________________

Turtleworks Pictures Worksheet

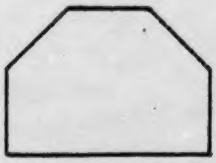
Materials: You need to be working in front of a PET computer.

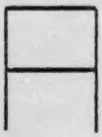
Find a way to draw each of the pictures below on the computer screen using Turtletalk. Write the program you end up using next to each picture. (You can use the LIST command to list your program.)

1.



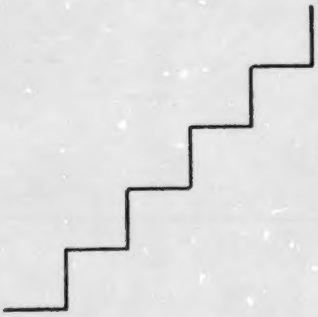
2. These pictures can be drawn with one turtle.



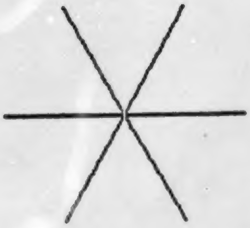


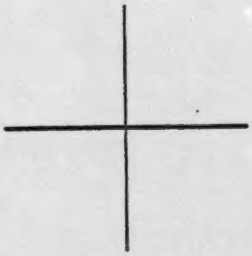
Turtleworks Pictures Worksheet

3. The REPEAT command will help here!



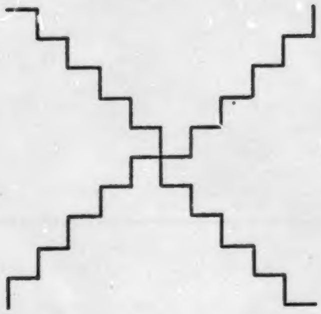
4. See if you can use MULTIPLYBY here.

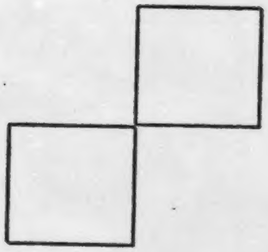


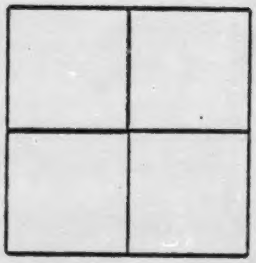


Turtleworks Pictures Worksheet

5. How about a combination of MULTIPLYBY and REPEAT?







Turtleworks Pictures Worksheet

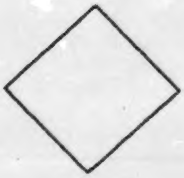
Create a design of your own. Write the program here and make a sketch of what it produces. Save your design on the MNCP network.

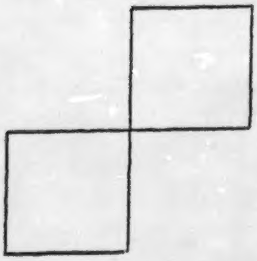
Look at some of the designs other groups have saved on the MNCP network. Try to figure out how they made them. Sketch one design you liked here and show its Turtletalk commands.

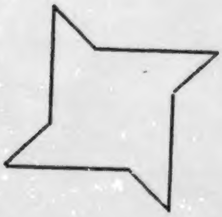
112

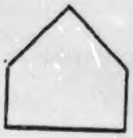
Turtleworks Pictures Worksheet

Here are some additional designs for you to try if you have time.





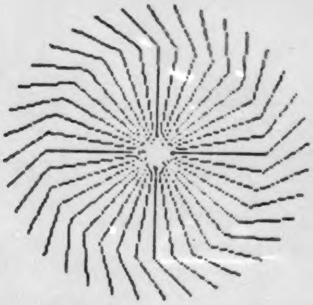




Name________________

Group_______________

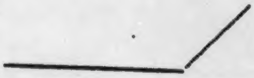
Date________________



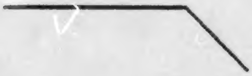
The Hook Worksheet

Materials: You need paper, pencil, and a **Turtle-Tractor.**

1. a) Below is a hook drawn by a turtle. Write the Turtletalk program which would draw the hook.



b) Suppose the hook goes the other way. Now what would the Turtletalk program be?



2. a) The Turtletalk program below puts 4 **hooks** together. Draw the figure using your Turtle-Tractor.

```
RPT 4 (GO 6 TURN 45 GO 3 TURN 45)
```

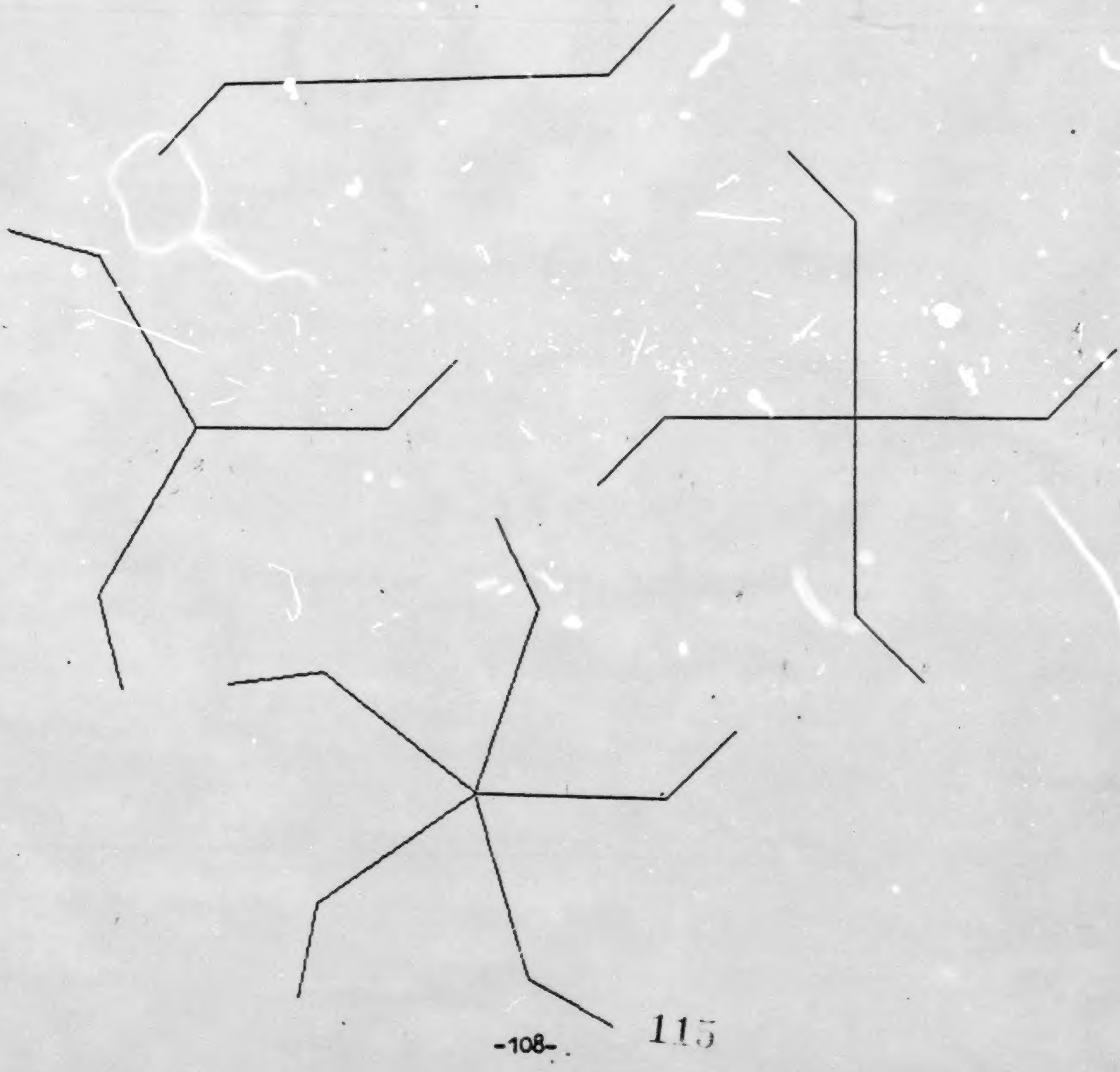
b) Find out what happens if you send the turtle the other direction.

```
RPT 4 (GO 6 TURN 315 GO 3 TURN 315)
```

The Hook Worksheet

3. Below are some figures drawn with hooks and some Turtletalk programs. Draw lines from each figure to its program.

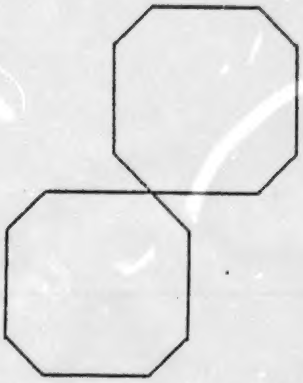
```
a) MULT 3 GO 6 TURN 45 GO 3 TURN 45

b) MULT 2 GO 6 TURN 45 GO 3 TURN 45

c) MULT 5 GO 6 TURN 45 GO 3 TURN 45

d) MULT 4 GO 6 TURN 45 GO 3 TURN 45
```



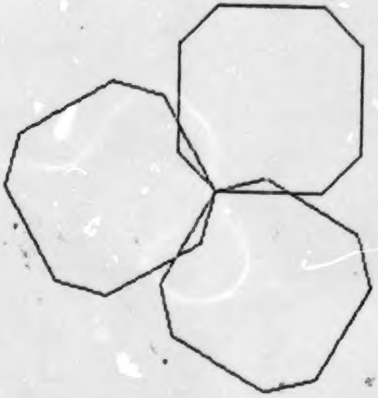
The Hook Worksheet

4. Combining the ideas of problems 2 and 3, we can get figures like those drawn below. Next to each figure, write its Turtletalk program. You do not need to use your turtle-tractor to actually make the drawing.

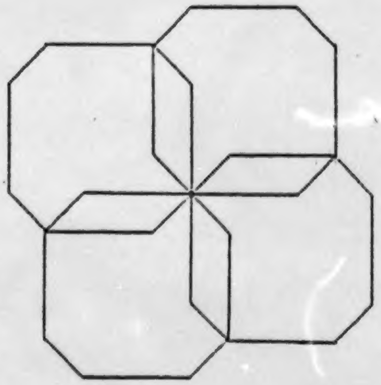
a)



b)



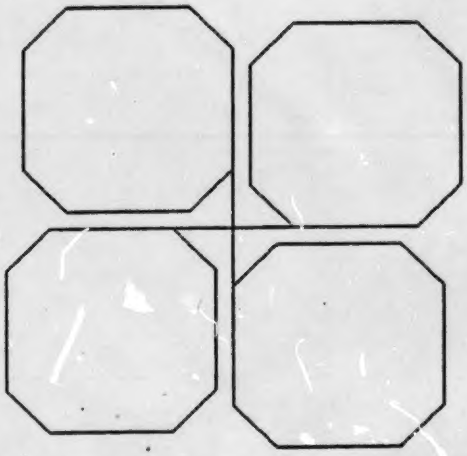
c)



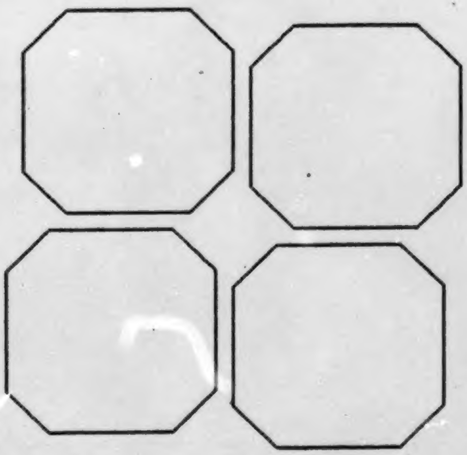
5. IF YOU HAVE TIME
   On the following pages are some more figures made with hooks. For as many of them as you can, write a Turtletalk program that could draw them.

Also, you might enjoy making up some **HOOK FIGURES** of your own.

a)



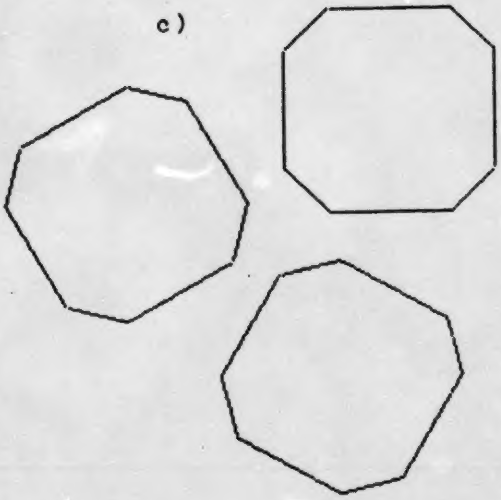
b)



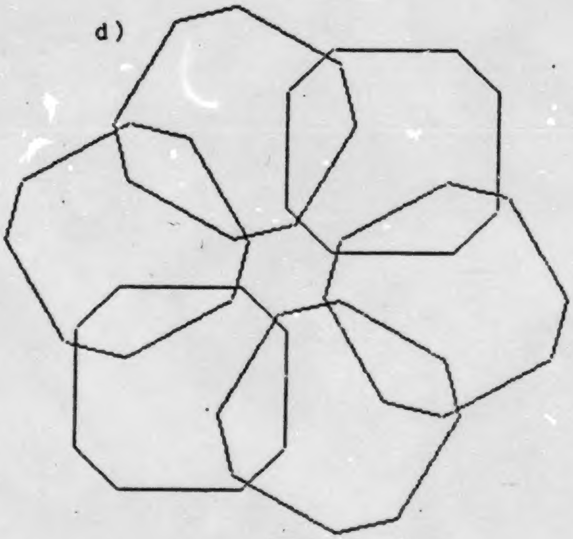
117

The Hook Worksheet

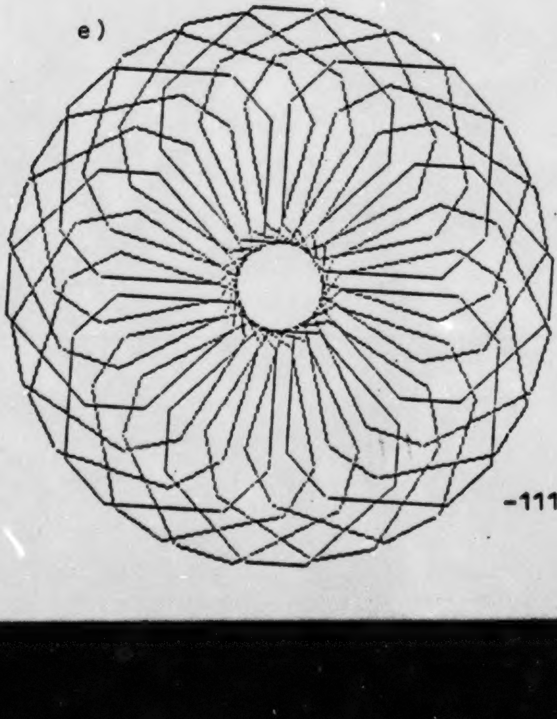
c)



d)



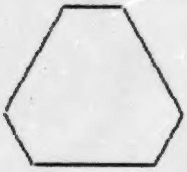
e)



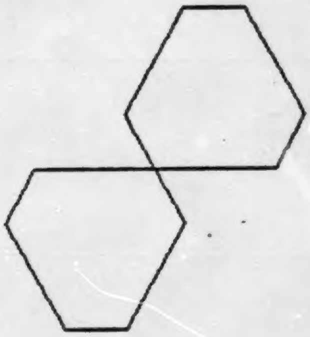
The Hook Worksheet

6. Still More Hooks

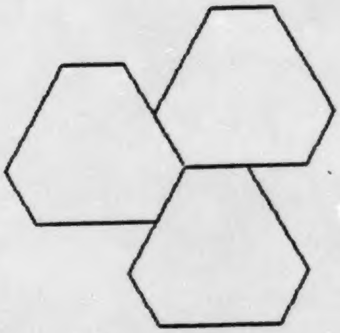
a)



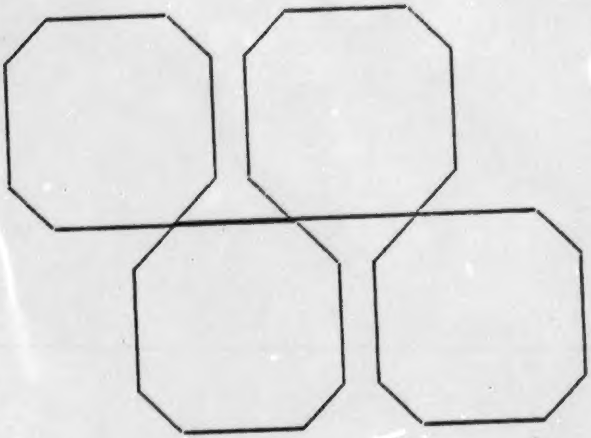
b)



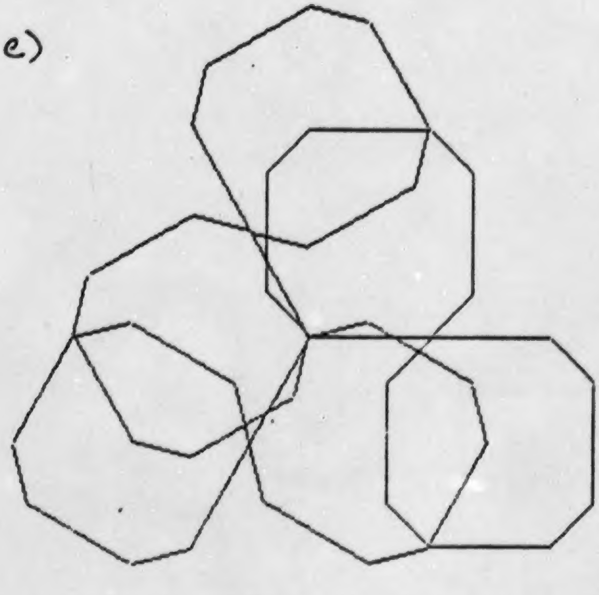
c)



d)



e)



SYMMETRY

Prerequisite Turtle Geometry

Time 2 hours, 30 minutes (long version) or
1 hour, 45 minutes (short form)

Materials

large, cut-out letters (F, A, H, X, S, and O)
overhead projector
1 Turtletractor
1 "Greek Letters Symmetry Worksheet" per teacher
1 set of Design Cards per 3 teachers
1 "Swirling Mirrors Worksheet" per teacher
1 PET computer loaded with "Turtleworks" program per 3 teachers
1 set of Polygon Rosette Cards per 3 teachers
1 "Polygon Rosette Worksheet" per teacher
1 "Symmetry Families Worksheet" per teacher

Suggested Time Frame

Time	Activity
5 min	Introduction
30 min	Alphabet Symmetry
20 min	Design Cards
20 min	The Polygon Rosette Family
40 min	Symmetry Families
5 min	Summary

Total: 2 hours

Overview for Master Teacher

Many of the MNCP units deal with number patterns. This unit, however, deals with recognizing visual patterns. Although this type of pattern recognition is useful in many careere (eg. engineering, biology, architecture), the development of pattern recognition skills is often neglected in the pre-college curriculum.

The Symmetry Unit provides students with practice in visual pattern recognition, while introducing the language of symmetry to describe some visual patterns. The unit also introduces students to ways in which complex designs can grow from very simple ones. They will explore this phenomenon by studying families of designs which have been created for them, and they will be able to build their own families.

The students were introduced to the Hook Family in the Turtle Geometry Unit. In this unit they will use a new command "To" in order to build their own designs.

The first three activities introduce students to the terms mirror symmetry and rotational symmetry and provide them with practice in recognizing these properties. In the fourth activity, "The Polygon Rosette Family," students meet a family of designs, and in the last activity they experiment with creating a family of their own.

Introduction

Time 5 minutes

Materials None

Be sure that teachers are aware of three things:

- The Turtle Geometry Unit is prerequisite to this unit.

- In this unit, they and their students will be working with visual patterns, and describing and understanding these patterns is an important branch of mathematics.

- Understanding symmetries leads to an understanding of our world (cf. "Overview" in the Teacher's Guide).

Alphabet Symmetry

Time 20 minutes

Materials
large, cut-out letters (F, A, H, X, S, and O)
overhead projector
Turtletractor
1 "Greek Letters Symmetry Worksheet" per teacher

Follow the introduction of Mirror and Rotational Symmetry as outlined in the Teacher's Guide. Be sure to model the suggested teacher behavior described there to allow teachers time to discover the pattern for themselves and to use teachers who discover the rule early as aides.

Work through the worksheet as a whole group. You will probably only have time to go over part of that worksheet.

Design Cards

Time 20 minutes

Materials

1 set of Design cards per 3 teachers
1 "Design Cards Worksheet" per teacher
1 "Swirling Mirrors Worksheet" per teacher

Have the teachers work in groups of threes on the "Design Cards Worksheet." If some groups finish that worksheet, they can move on to the "Swirling Mirrors Worksheet." The latter worksheet would make a good homework problem for teachers.

The Polygon Rosette Family

Time 20 minutes

Materials

1 PET computer loaded with "Turtleworks" program per 3 teachers
1 set of Polygon Rosette cards per 3 teachers
1 "Polygon Rosette Worksheet" per teacher

Have teachers work in groups of three with the cards on a large flat area away from the computers. They can walk over to the computer to check their Turtletalk programs if they get to the back of the worksheet.

Stop the teachers about 5 minutes before the end of the activity. As time permits, go over the discussion questions in the Teacher's Guide.

Symmetry Families

Time 40 minutes

Materials

1 PET computer loaded with "Turtleworks" program per 3 teachers
1 "Symmetry Families Worksheet" per teacher

Have one computer placed so that everyone can see its screen.

Introduce the "To" command as described in the Teacher's Guide.

Now let the teachers work in groups at the computer with the worksheets. Groups can share their work with other groups during the last five minutes of the activity by moving around to other computers to see a representation of that group's problem on the screen. They can also look at the other group's worksheet.

Summary

Time 5 minutes

Materials None

Spend this time talking about what the teachers learned about finding visual patterns and symmetries in this session. Spend a little time discussing why the skills students will learn about in this unit are important ones.

Name____________________

Other Group Members________________________

Date____________________

Greek Letters Symmetry Worksheet

Ancient Greeks used a different alphabet than the one we use now (the Roman alphabet). Below are listed the small letters in their alphabet with the names underneath.

α	β	γ	δ	ϵ	ζ
alpha	beta	gamma	delta	epsilon	zeta
η	θ	ι	κ	λ	μ
eta	theta	iota	kappa	lambda	mu
ν	ξ	ο	π	ρ	σ
nu	xi	omicron	pi	rho	sigma
τ	υ	ϕ	χ	ψ	ω
tau	upsilon	phi	chi	psi	omega

1. Which of the Greek letters have no symmetry?

2. Which of the Greek letters have one line of mirror symmetry?

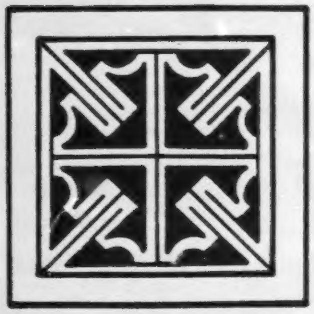
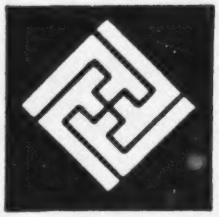
Greek Letters Symmetry Worksheet

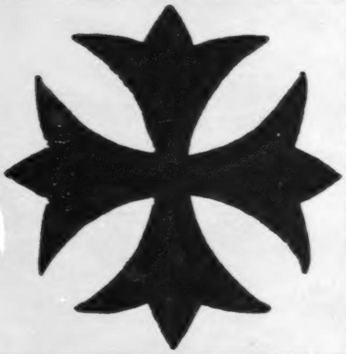
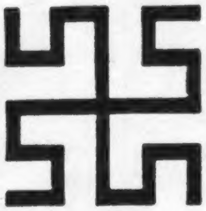
3. Which of the Greek letters have more than one line of mirror symmetry?

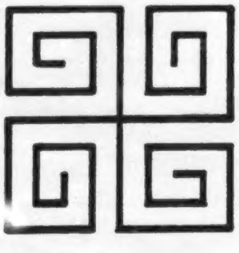
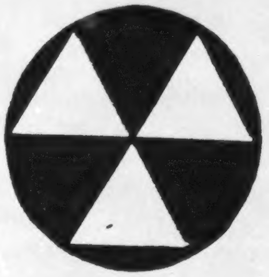
4. Which of the Greek letters have rotational symmetry?

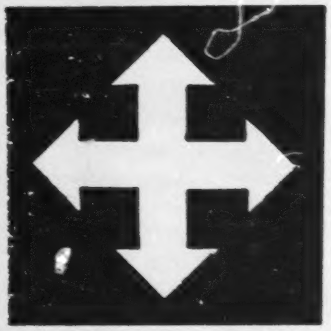
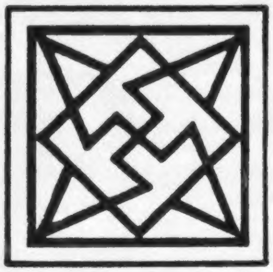
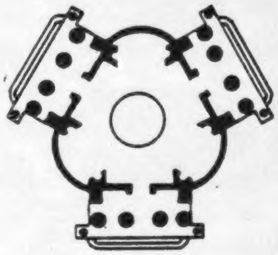
5. Which of the Greek letters have both rotational and mirror symmetry?

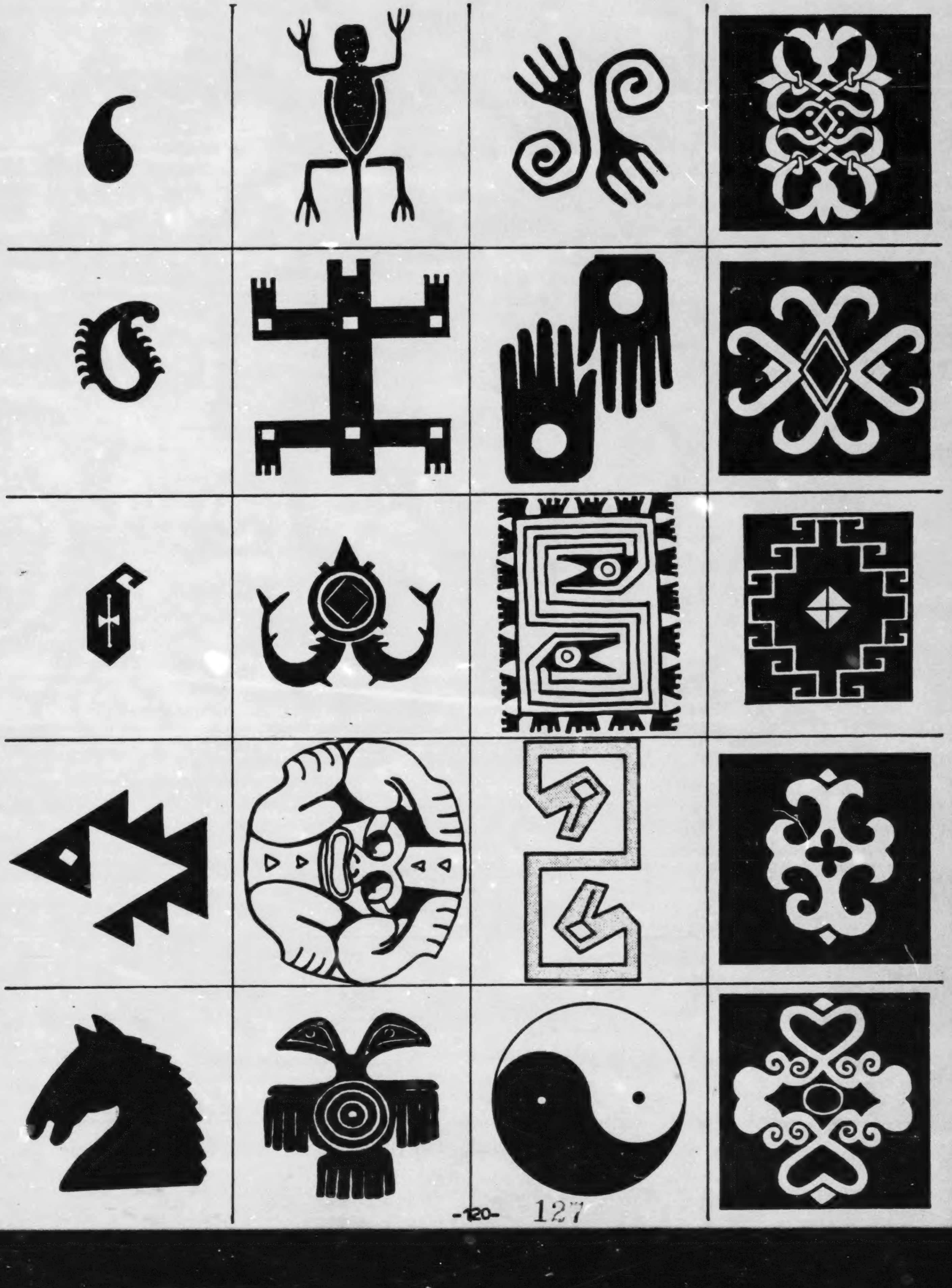
6. Which of the Greek letters have rotational but not mirror symmetry?



Name________________________

Other Group Members____________________

Date________________________

Swirling Mirrors Worksheet

Materials: You need a set of 'Design Cards' and your records from the 'Design Cards Worksheet.'

1. In your work with the Design Cards, you probably realized that there were lots of kinds of symmetry that could have been present and were not. For example, there were no designs that had five lines of mirror symmetry and 72 degree rotational symmetry.

   Name another possible kind of symmetry that none of the cards have.

   Sketch a design that has that kind of symmetry.

2. Two of the following kinds of symmetry are impossible! Which two are they?

   (a) two lines of mirror symmetry and 90 degree rotational symmetry

   (b) six lines of mirror symmetry and 60 degree rotational symmetry

   (c) three lines of mirror symmetry and no rotational symmetry

Swirling Mirrors Worksheet

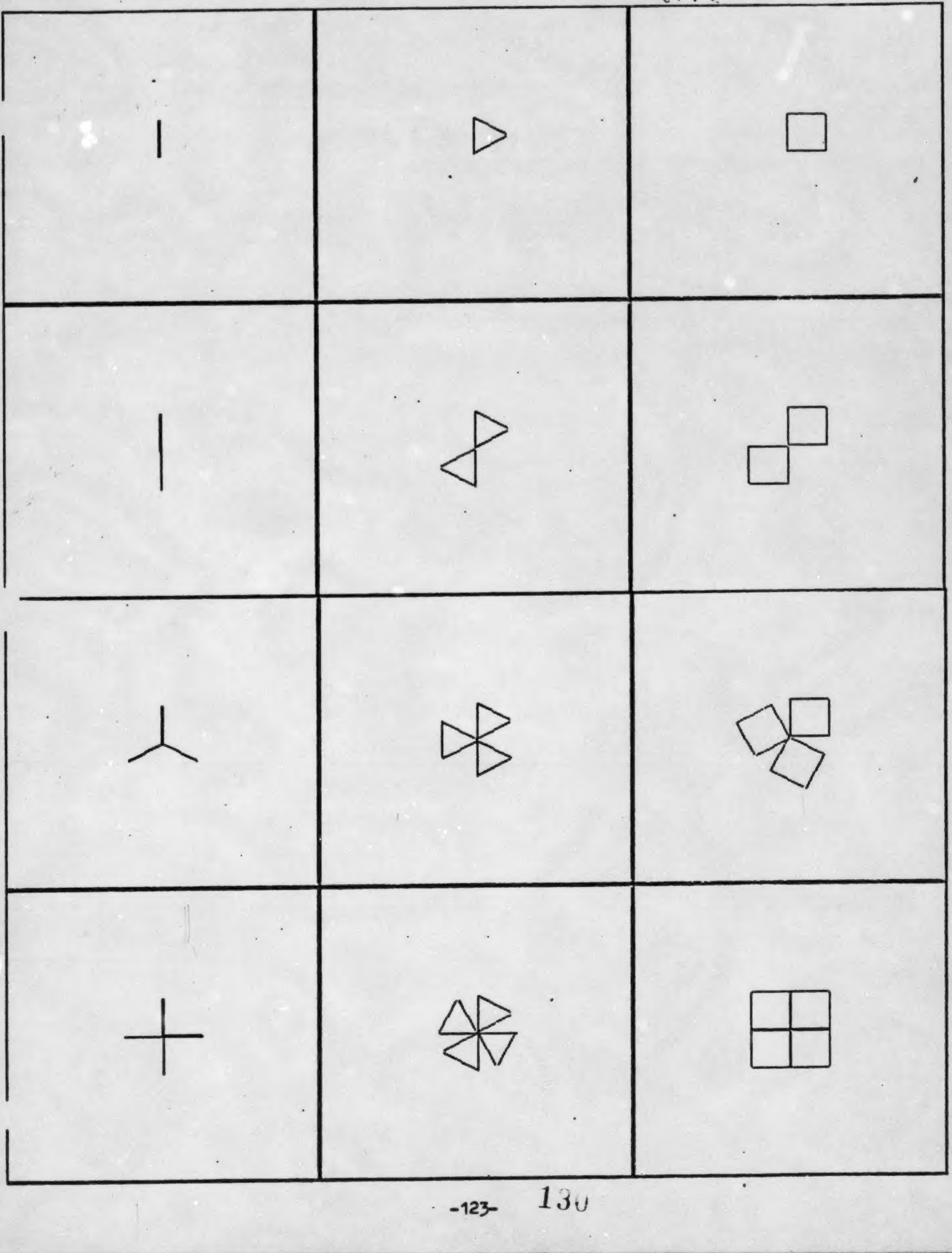
3. **The Relationship Between Mirror Symmetry and Rotational Symmetry**
Fill out the chart below with all the kinds of symmetry you have met so far. For example, the first line has been filled out to represent designs with 2 lines of mirror symmetry and 180 degree rotational symmetry.

Number of Lines of Mirror Symmetry	Degree of Rotational Symmetry
2	180

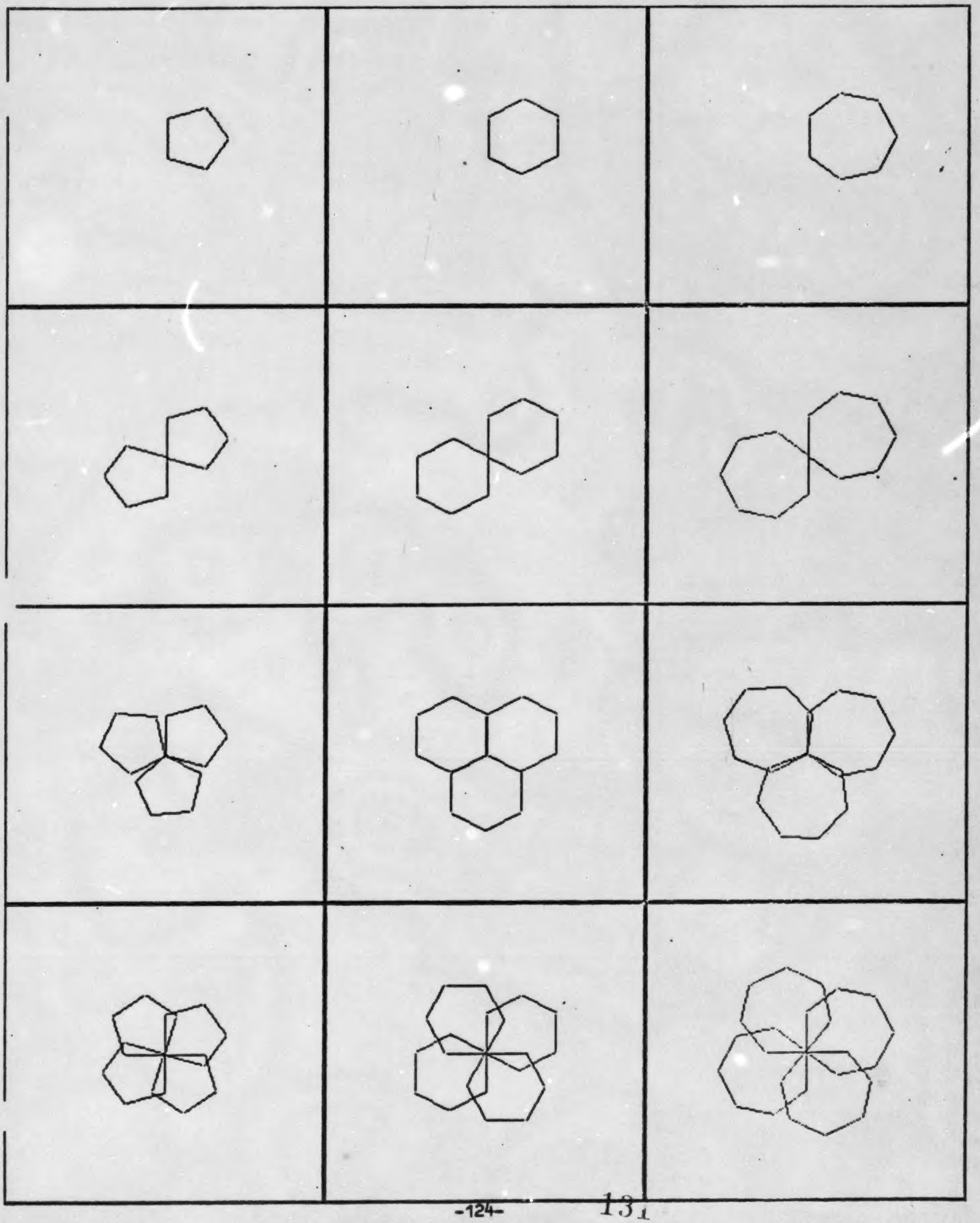
Look only at the lines in the table that do have rotational symmetry. What relationship do you see between the left column and the right column?

Describe the relationship here.

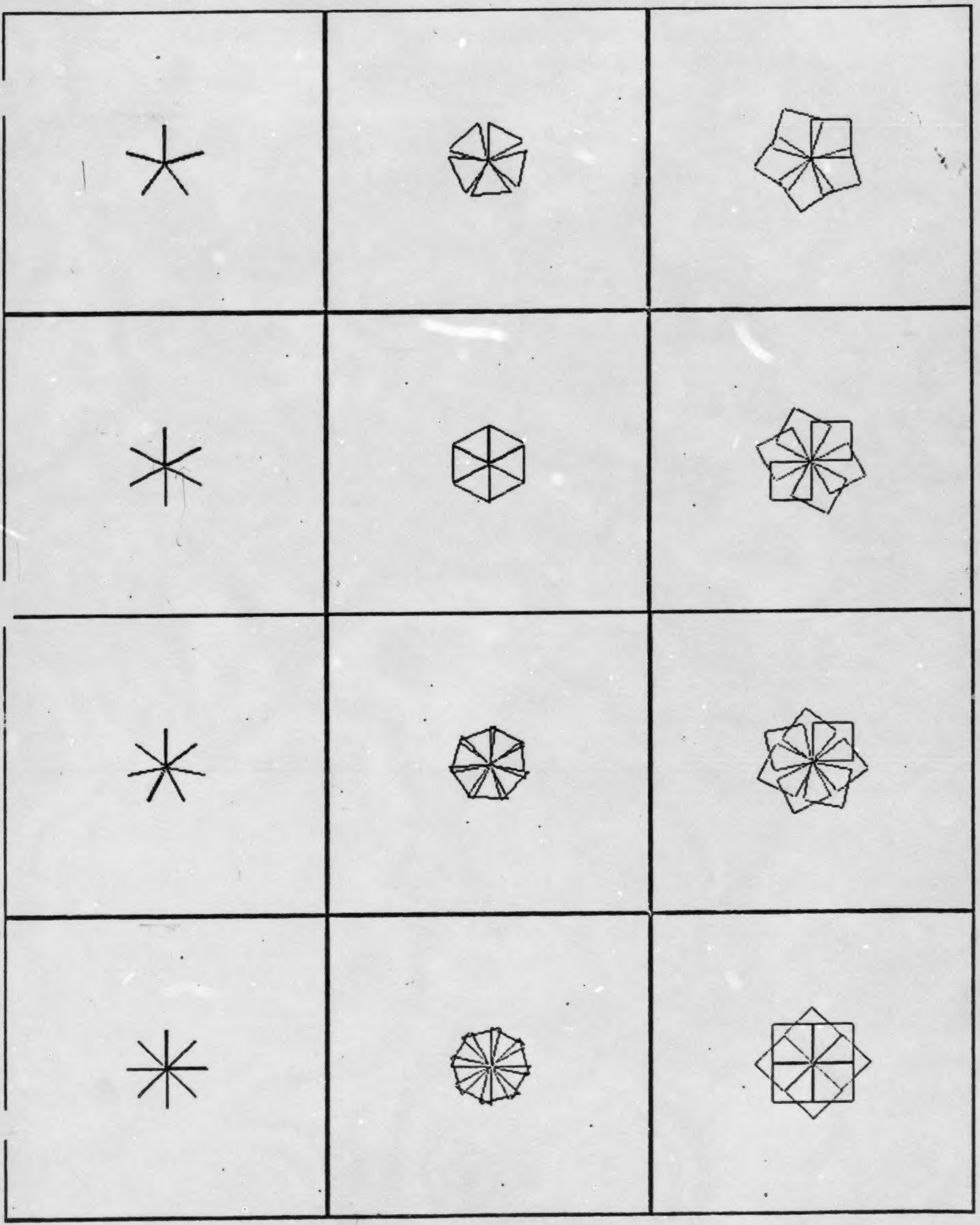
white



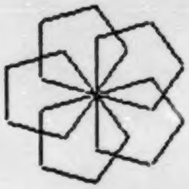
White

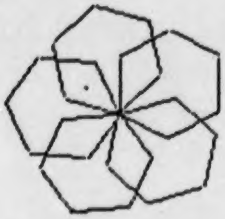


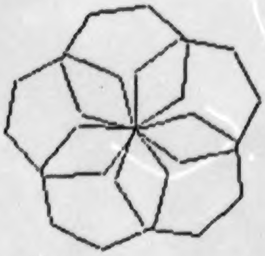
White

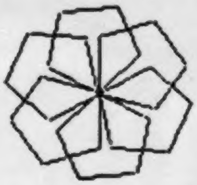


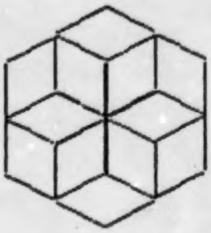
White

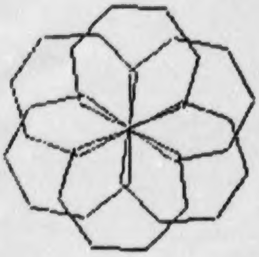


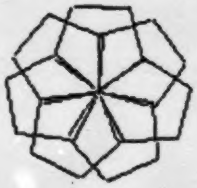


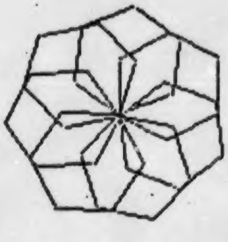


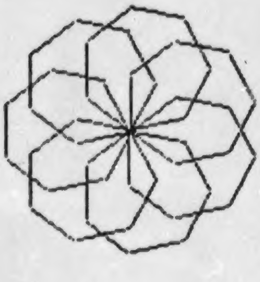


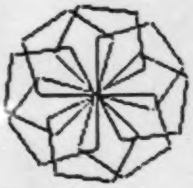


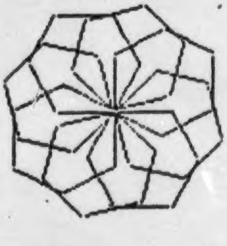


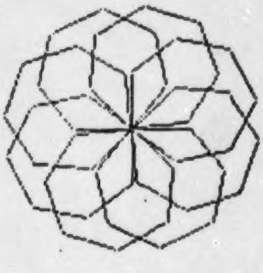




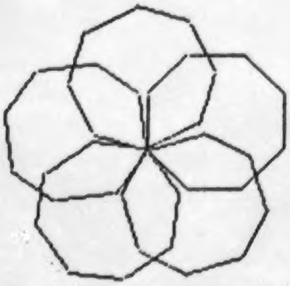


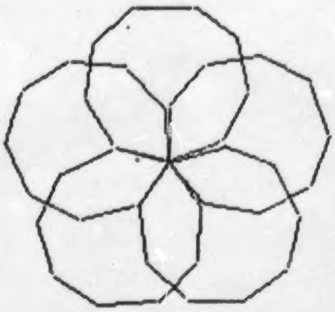


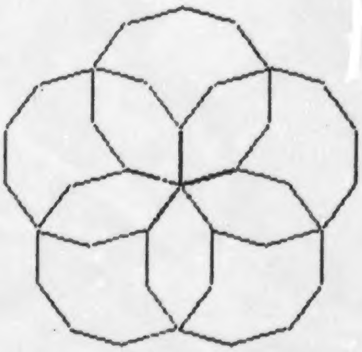


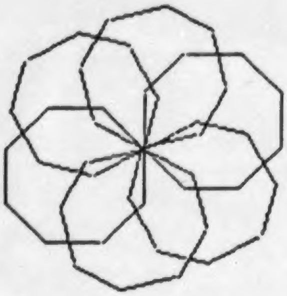


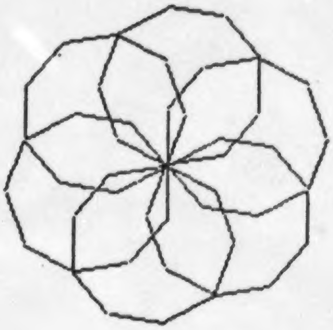
Blue

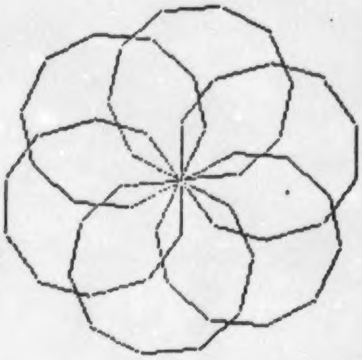


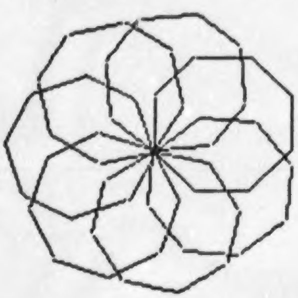


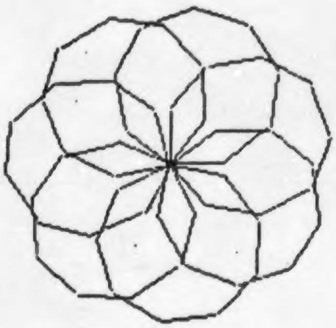


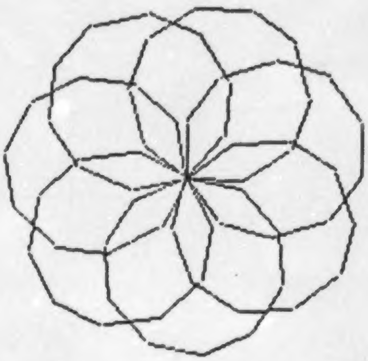


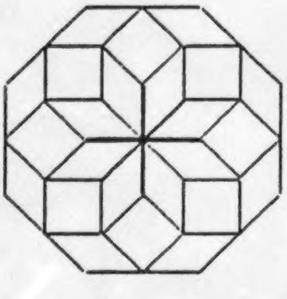


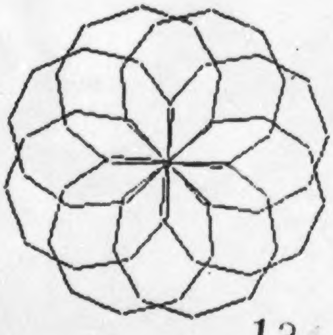


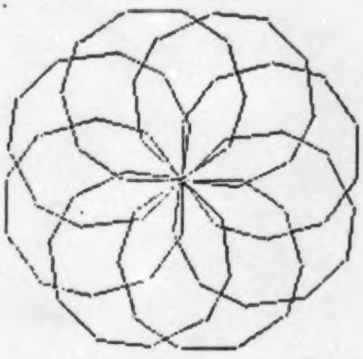




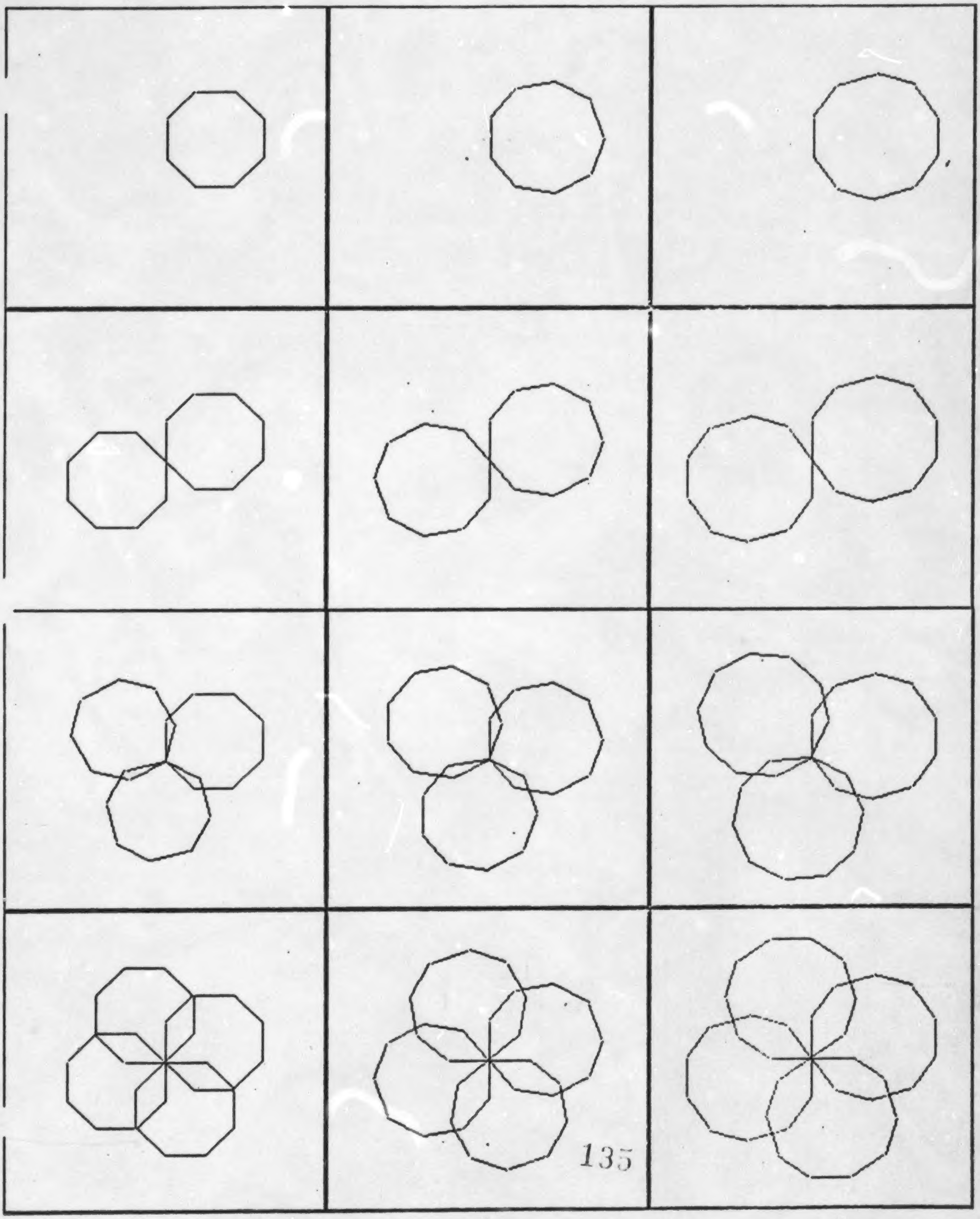




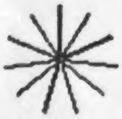


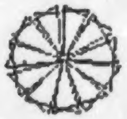


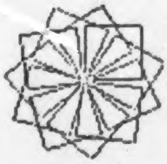
Blue

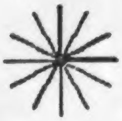


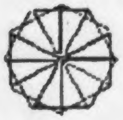
Blue

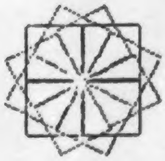


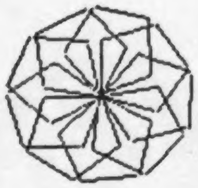


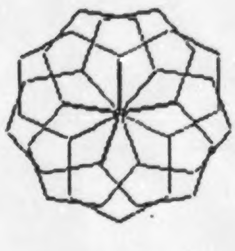


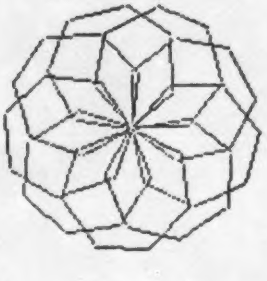


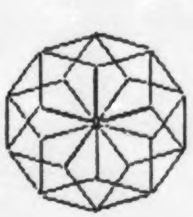


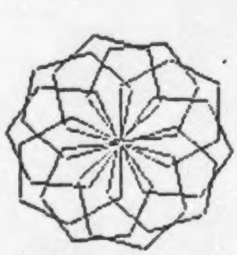


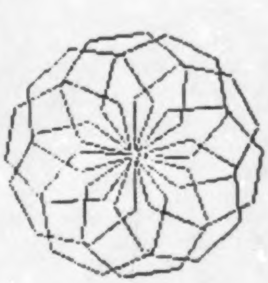






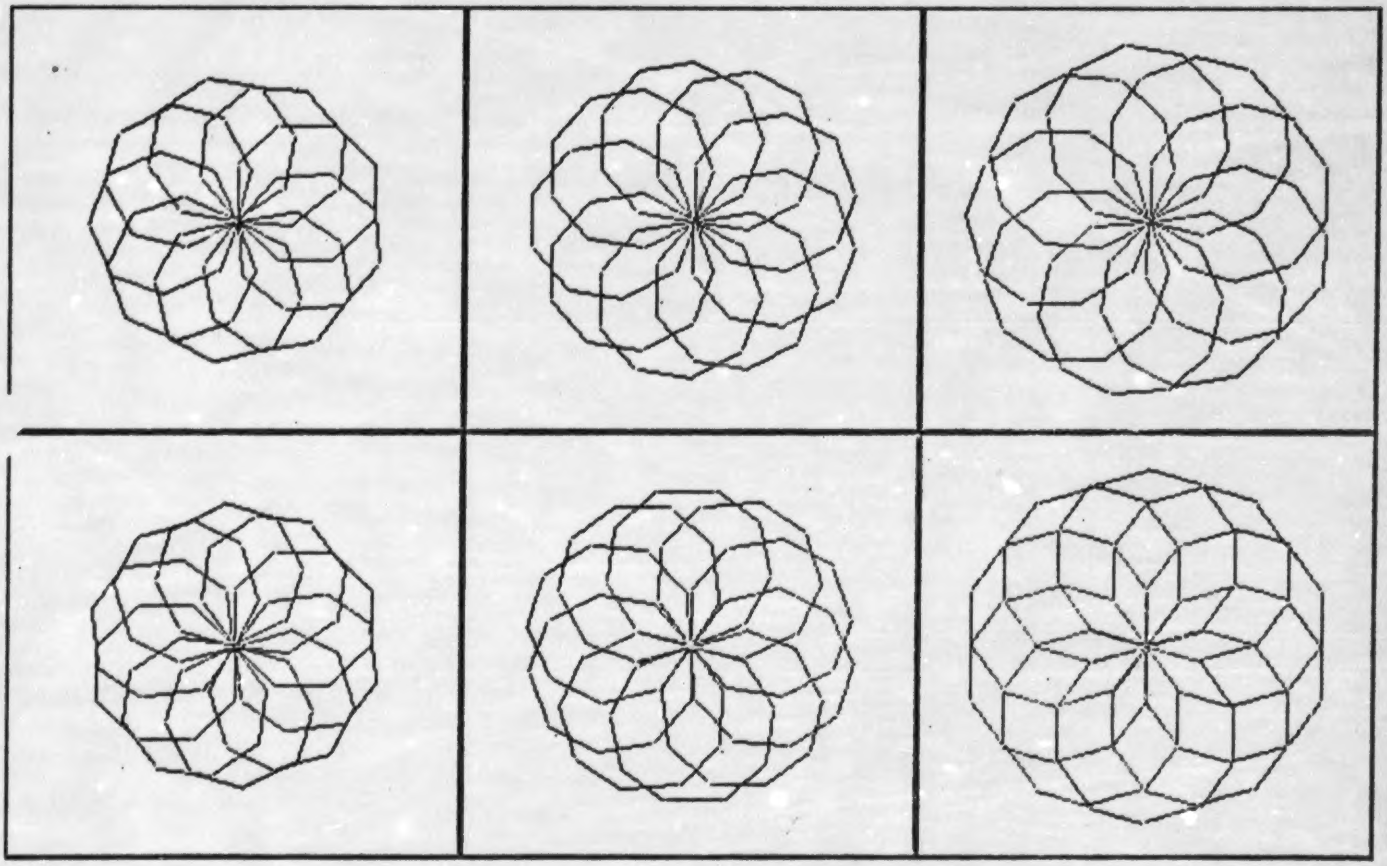






136

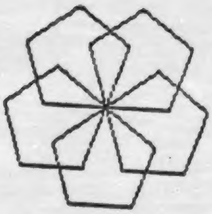
Blue



Name____________________

Other Group Members____________________

Date____________________



The Polygon Rosette Family Worksheet

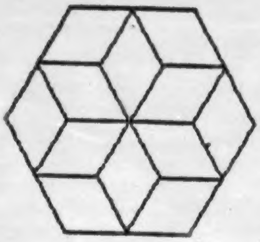
Materials: You need a set of 'Polygon Rosette cards' and a fairly large flat area (the floor or a table will do fine).

1. Spread out the cards so you can see most of them. Your task is to 'organize' the cards in a system which makes it easy to see the similarities and differences between different cards. When you are done, all the cards will be visible and there will be a kind of pattern to the way the cards are arranged. Describe your system here.

2. If you have done a good job of laying out the cards, it should be easy for you to find each of the patterns listed below. See if you can. You may find you want to revise your arrangement. For each card, describe where it lies in your pattern.

Description of card	Place in pattern
3 squares	
5 triangles	
3 hexagons (six sides)	
4 heptagons (seven sides)	
8 heptagons	

Describe in writing here why you decided to put the cards with single lines where you did.



Polygon Rosette Family Worksheet

3. These cards were produced by a computer which understands Turtletalk. You should be able to write a Turtletalk program to produce any of the cards. Pick two cards and figure out their programs.

Description of card	Turtletalk Program
1.	
2.	

4. Each of the two Turtletalk programs below will draw one of the cards. Describe the appropriate card in the right-hand column.

Program	Description of card
1. MULT 7 RPT 4 (GO 10 TURN 90)	
2. MULT 6 RPT 5 (GO 10 TURN 72)	

5. Some of Polygon Rosettes belong together in a special way. For example, look at the **four squares**. See how they come together to make a single larger square. What other card does the same kind of thing?

If you have the extended set of Polygon Rosette cards (the extra cards are colored blue), find two other cards in which the small shapes also come together to make a single larger shape with the same outline. What are they?

Find **another special family** of Polygon Rosette cards. Describe that family here.

Name______________________

Other Group Members____________________

Date______________________

Symmetry Families Worksheet

Materials: You need to be working in front of a computer loaded with the Turtleworks program.

1. **Making a Design Out of Parts**
   You can teach the turtles new words. Here is an example. Type in each line, hitting <return> at the end of each line.

```
TO POP
GO 8 MULT 3
TURN 45 GO 4
END
```

   You have just told the turtles what POP means and you can see what it means on the screen. From now on you can use the command POP just like any other Turtletalk command.

   Try this:

```
CLEAR
MULT 3
POP
```

   and this:

```
CLEAR
POP 3
```

   Play around with POP a bit before going on.

2. **Make Your Own**
   As a group, try teaching the turtles a new command of your own. The first thing you type in is

```
TO
```

   followed by whatever you choose to name the command.

   The last line of the definition of the command must be

```
END
```

Symmetry Families Worksheet

Write the name and definition of your command here:

```
TO _______________




END
```

3. **Using Your New Command**
See what happens when you

```
CLEAR
MULT 2
```

and then issue your command.

Does the design created have rotational symmetry? _____If so, what degree? _______

Does the design created have mirror symmetry? _____
If so, how many lines of mirror symmetry? _______

Find a way to use your command to create a design with 60 degree rotational symmetry. Write how you did it here:

Experiment with different symmetries you can get using your new command. Record the program that produced the most pleasing effect here:

Symmetry Families Worksheet

4. **Your Own Symmetry Family**
With your new command, you can create 'families' of designs. Here are three designs which are members of a family. Try them.

```
CLEAR          CLEAR          LEARCLEAR      CLEAR
MULT 2         MULT 3         MULT 4
POP            POP            POP
```

Show how you would use your new command to create a 'family' of designs, each of which has a different symmetry from all the others. Describe your family here.

Show the basic program that you used to create your family. Indicate which parts of the program change to get new members of the family.